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Wood Use

U.S. Competitiveness and Technology

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Foreword

The Office of Technology Assessment has conducted an assessment of the role of technology in the U.S. forest products industry. It was undertaken at the request of Senator Mark Hatfield, Chairman of the Senate Committee on Appropriations, and Senator Thad Cochran, Chairman of the Subcommittee on Agriculture, Rural Development, and Related Agencies. Representative James Weaver, Chairman of the Subcommittee on Forests, Family Farms, and Energy, joined in support of the assessment in the House of Representatives.

This assessment surveys the contribution of the forest products industry to the U.S. economy, the ability of the industry and the U.S. forest resource to satisfy expected domestic demands for wood, the competitiveness of U.S. forest products on world markets, and the role of technology in stretching the U.S. forest resource and providing products that satisfy domestic needs as well as international markets. It discusses the relationship of various levels of government and the forest products industry in providing for future wood products needs. Finally, it presents policy options designed to enhance the advantages of U.S. producers in international markets, to provide research and development in forest management, environmental effects of forestry, and wood materials science, and to improve the productivity of U.S. forests.

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NOTE: OTA is grateful for the assistance of its project advisory panel, chaired by Larry Tombaugh, and the members of its Wood Science and Technology Working Group and for the advice of numerous reviewers in agencies of the U.S. Government, academia, and industry. However, OTA assumes full responsibility for its report, which does not necessarily represent the views of individual members of its advisory panel or working group.

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Organization of the Assessment

Volume I of the assessment is organized as follows:

- Chapter I provides an overview and summary of the report and a tabulation of key issues and legislative options for congressional consideration.
- Chapter II contains a more detailed discussion of these issues and options.
- Chapter III discusses international trade in wood products and summarizes the implications of world demand and supply for the U.S. timber resource and the forest products industry.
- Chapter IV describes the range of uses of wood and forest products in the U.S. economy and evaluates the impacts that current trends may have on domestic wood demand and supply in the future.
- Chapter V reviews the technologies available for increasing the growth and productivity of American forests and assesses the potential for harvesting technologies to expand supply by recovering larger proportions of timber at harvest. It also summarizes the status of manufacturing technologies that are covered in detail in volume II.
- Chapter VI reviews the U.S. forest resource base and weighs constraints for ensuring that future wood demands are met.
- The appendix to volume I includes a glossary of terms which the reader may find useful in understanding forestry terminology.

Volume II of this report contains a detailed review and assessment of manufacturing technologies and trends in end-use design for wood products.

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Overview

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CHAPTER I

Overview

Summary

The United States could greatly expand its role in world forest products trade over the next decade and could become a net exporter of solid wood and paper products before 1990. For the past 30 years, the United States typically has imported more forest products than it has exported. Because exports have grown faster than imports, the trade deficit has narrowed. This trend is likely to continue.

Global demand for a wide range of forest products is growing rapidly, but the best trade opportunities for U.S. producers appear to be in the paper markets of other industrialized nations, particularly Western Europe and Japan. In contrast to many basic U.S. industries, the forest products industry has distinct advantages over its foreign competitors. The U.S. forest products industry is the most productive and among the most efficient in the world, and it benefits from a vast and highly productive domestic forest resource.

The United States and Canada are expected to remain the world's largest mutual trading partners in wood products, continuing to exchange those products for which one country has a competitive advantage over the other. Continued imports of Canadian low-value lumber and newsprint may result in greater opportunities for U.S. producers to export products such as linerboard and high-value lumber where the U.S. competitive edge is greatest.

To capitalize on international trade opportunities, the forest products industry and the Federal Government probably will have to make concerted efforts to promote exports. Although responsibility for developing foreign markets rests primarily with the private sector, government action will be needed to overcome trade barriers that currently inhibit the competitiveness of U.S. wood products in foreign markets.

Past Government and private sector concerns regarding a possible domestic timber shortfall no longer seem justified. Future timber needs, especially for housing but also for other products, probably have been overestimated. The effects of intensive timber management and the ability of wood utilization technology to stretch the wood resource have probably been underestimated.

If current trends toward more intensive forest management continue, domestic needs for wood probably can be met without dramatic price increases. However, substantial investments in forest management would be required to increase wood production beyond the levels expected to result from current trends. U.S. timber harvests can be more than doubled over the long term through increased application of intensive forest management technologies such as applied genetics, fertilization, and improved harvesting systems. To achieve the full economic potential of U.S. forestlands, an estimated investment of $10 billion to $15 billion would be needed over the next 30 to 50 years.

Existing and emerging technologies enable a broad range of wood products to be manufactured from currently underutilized hardwood species and from waste wood material. For example, high-strength papers now are made from hardwoods, once considered impossible. Many manufacturing technologies are available which have not been commercialized, but future economic conditions probably will warrant commercialization of many of these, and research and development (R&D) will continue to play an important role in the introduction of new products.

Several factors could affect future timber availability. However, none is expected to be a serious future limitation to wood supply,

unless demand increases dramatically without adoption of intensive forest management and wood utilization technologies. These factors include a shrinking forestland base, a large portion of U.S. forests in private nonindustrial ownership that may not be managed for commercial timber production, and the recent trend toward significantly increased use of wood fuel.

Commercial timber production is only one of many uses for U.S. forestland. Other uses include wildlife habitat, rangeland, watershed protection, wilderness, and recreation. Achieving a balance among many forest uses, especially on Federal lands, is a fundamental part of U.S. public lands policy. Broad-scale intensive forest management may result in increased soil loss, altered wildlife habitat, reduced water quality, and lower soil productivity. The environmental impacts of intensive forestry are not well understood, and further research on its effects may be needed.

Significant changes in Federal programs and policies probably are not required to ensure that future domestic forest products needs are met. However, OTA has identified several policy options which, if implemented, could help to increase the competitiveness of the forest products industry. There are five general types of options:

1. Establish national objectives for management and use of the Nation's forest resources.
2. Encourage research, development, and transfer of forestry-related and wood utilization technologies.
3. Increase international competitiveness of U.S. forest products.
4. Improve the quality of information needed for forest policy formulation.
5. Improve systems for identifying timber management needs.

Introduction

The Senate Committee on Appropriations requested that the Office of Technology Assessment (OTA) undertake an assessment of technologies related to the growth and use of U.S. timber resources. OTA found that the technologies were tied closely to the economic conditions affecting the forest products industry and the resource base. With the concurrence of the committee, OTA broadened its assessment to include an evaluation of the role of wood in the U.S. economy. Subsequently, the House Subcommittee on Forests, Family Farms, and Energy wrote to OTA affirming its interest in the assessment.

In response to this congressional interest, OTA undertook a study to answer the following general questions:

- What is the status of technology for increasing the efficiency of wood use in the manufacturing process, for increasing the productivity of U.S. forestlands, and for recovering a larger proportion of timber during harvesting?
- Do Forest Service projections of demand and supply accurately reflect the future potential of technology?
- What is the status of worldwide timber demand and supply, and how will global conditions affect U.S. wood futures?
- Is the manufacturing capacity of the U.S. forest products industry adequate to meet future needs?
- Is U.S. R&D balanced and adequate enough to achieve national goals in the growth, harvesting, and utilization of the timber resource?

To answer these questions, OTA first reviewed in detail the existing, emerging, and possible future technologies for converting timber into commercial wood products. Second, technologies for increasing the growth and productivity of the resource and for harvesting timber and transporting it to mills were assessed. Third, based on the potential for technology to increase the capacity to grow timber and manufacture wood products, OTA assessed the status of the U.S. timber resource. Finally, projected domestic and foreign demand for wood products was compared to the ability of various timber-producing nations to meet future global needs.

Federal Forest Management and Policy

The U.S. Department of Agriculture's (USDA) Forest Service has primary responsibility within the Federal Government for administering programs affecting forest resources and wood utilization. The Forest Service manages the National Forest System, which encompasses 190 million acres of forestland located primarily in the West. Approximately half the acreage in national forests is considered to be suitable for commercial timber production. The National Forest System is the Nation's largest single reserve of standing sawtimber and represents about 41 percent of the total U.S. sawtimber resource, consisting mainly of high-value softwood species. Because it is so large, the National Forest System provides nearly one-fourth of the softwood sawtimber consumed annually in the United States. The management of Forest Service lands must accommodate a broad range of uses; therefore timber production may not be maximized in areas where other resource values compete.

Other agencies within USDA also share responsibility with the Forest Service for forestry-related activities. These include the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, the Foreign Agricultural Service, the Cooperative Extension Service, the Science and Education Administration, and the Federal Crop Insurance Corporation. The Bureau of Land Management in the Department of the Interior manages forestlands primarily in Oregon, and the Tennessee Valley Authority undertakes cooperative forestry programs with States and private agencies in the Tennessee Valley region.

Several other Federal agencies also could play prospective roles in facilitating the further development of domestic and international

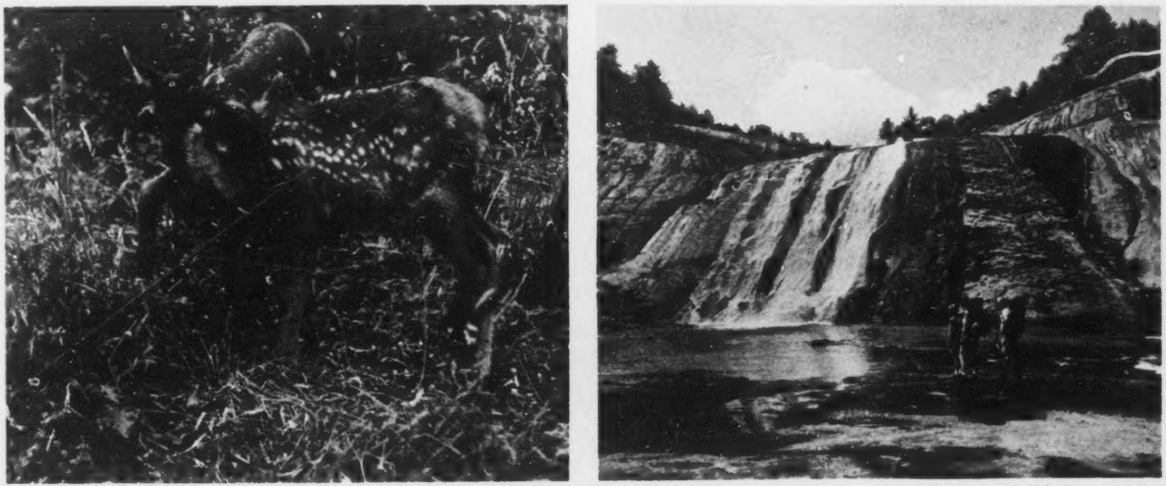


Photo credit: U.S. Forest Service

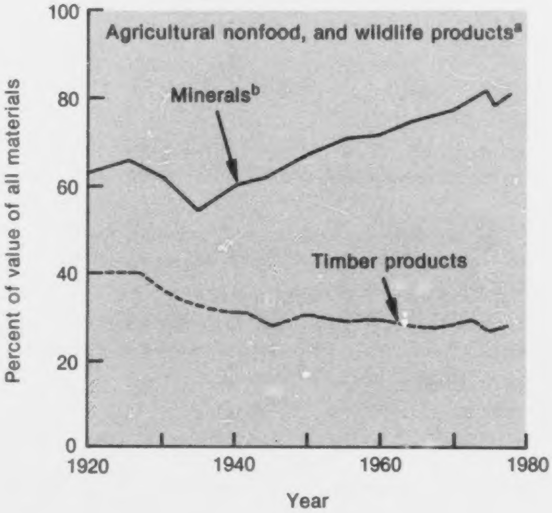
Wildlife and recreation are part of a range of multiple-use management on the National Forest System markets for U.S. forest products, including the Departments of Treasury, Commerce, and State, and the Office of the U.S. Trade Representative. Most of these agencies have from time to time been involved in forest products-related issues, but not in a focused, coordinated manner.

During the past decade, Congress established a comprehensive assessment and reporting system for forest resources, reaffirming a commitment to resource evaluation articulated in the McSweeney-McNary Act of 1928. The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (Public Law 93-378), as amended by the National Forest Management Act (NFMA) of 1976 (Public Law 94-585), directs the Forest Service to assess timber supply and resource requirements every 10 years. Based on each assessment, the Forest Service is directed to formulate 5-year programs that present strategies for achieving national goals. Each assessment and program are used in the Federal budgeting process and serve as guides for the administration of Forest Service programs. However, NFMA's emphasis on the National Forest System limits the usefulness of the RPA assessment and program for guiding national efforts to expand and use timber resources, although there are modest Federal programs to increase forest productivity in the private sector.

Forest Products Industry

Wood was the single most important industrial material in the early development of the U.S. economy. It was essential to most forms of construction and manufacturing and as fuel. After 1920, its role began to decline, so that wood now accounts for only about 26 percent of the value of major industrial raw materials (fig. 1). Despite its smaller contribution to today's economy, the volume of wood used for industrial purposes since the beginning of the century has increased from approximately 8 billion cubic feet (ft^3) to more than 13 billion ft^3 annually due to population expansion and economic growth.

Figure 1.—Relative Importance of Industrial Raw Materials, 1920-77



[a] Includes cotton and other fabrics, oils, rubber, furs, hides, and other similar products.

[b] Includes mineral construction materials, metal ores, chemical and fertilizer materials, abrasives, and other minerals.

SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 3.

The U.S. consumes more forest products, nearly 70 ft^3 per capita per year, than any country in the world and accounts for about one-fourth of total world consumption. It is also the leading industrial source of forest products, producing 35 percent of the world's paper, 45 percent of its plywood, and 20 percent of its softwood lumber. The properties of wood make it adaptable to a wide variety of uses (table 1), with domestic production linked

Table 1.—Representative Uses for Wood

Uses/Examples
Construction:
Residential housing construction and upkeep, mobile homes, and light commercial structures; arches and beams for sports arenas, convention centers, etc.
Communications:
Newsprint, printing papers, and other paper products
Packaging:
Bags, sacks, containers
Furniture manufacturing:
Household and commercial furniture
Shipping:
Pallets, containers, dunnage, blocking, and bracing
Transportation:
Railroad ties, manufacture of railroad cars, boats, and light airframes
Wood fuel:
Fuelwood, woodchips, mill residues, etc.:
Residential home heating and cooking, forest products industry process energy, electricity generation
Liquid and gaseous fuels:
Potential supplement for petroleum and natural gas as a fuel or alternative petrochemical feedstock
Chemicals and cellulosic fibers:
Rayon and cellulose acetate:
Clothing fibers, tires, conveyor and transmission belts, ribbons, films, etc.
Silvichemicals (naval stores and pulping byproducts):
Used in production of synthetic rubber, chewing gum, rosin bags, inks, adhesives, paints, soaps, detergents, solvents, odorants, bactericides, drilling mud thinners, dispersants, leather tanning agents, water treatment, pharmaceuticals, etc.
Food and feed products:
Feed molasses, animal fodder, vanillin flavoring, food grade yeast products
Miscellaneous and specialty products:
Utility poles, pilings, fencing, mine props, cooperage, activated carbon, sporting goods, musical instruments, pencils, caskets, signs and displays, etc.

SOURCE: Office of Technology Assessment.

closely to construction, packaging, and communications requirements:

- About 60 percent of solid wood products (lumber, plywood, and panels) was used in construction in 1976, chiefly in new homes but also for home restoration and remodeling and nonresidential construction. Significant volumes of solid wood products also are used for shipping pallets and containers and in furniture and cabinets.
- The pulp and paper sector produces about equal amounts of paper and paperboard (cardboard, linerboard, and other stiff, thick papers). High-volume paper uses include printing and writing papers (51 percent), newsprint (17 percent), tissues (14.5 percent), and packaging (17.7 percent). Packaging materials (both paper and paperboard) accounted for about 60 percent of domestic paper and paperboard production in 1981.

Fuelwood for residential use recently has reemerged as a major, high-volume timber use. Most residential fuelwood is cut for personal use by homeowners and is not considered an industrial forest product in this report.

Structure of the Industry

The two major divisions of the forest products industry—the pulp and paper sector and the solid wood (lumber and panel) products sector—display significantly different characteristics and performance:

- The solid wood products sector employs more people. The value added to products in manufacture is greater in the capital-intensive pulp and paper sector.
- Demand for paper products is dependent on general economic conditions, while demand for lumber and panels is dependent on highly cyclical new home construction, which consumes nearly 40 percent of solid wood products.
- The pulp and paper sector is more concentrated than the solid wood products sector, with the 10 largest firms accounting for more than half the pulp, paper, and paperboard products manufactured in North America; the lumber industry (the most competitive subgroup of the solid wood sector) is far less concentrated, with 50 percent of its output produced by 800 firms.

Primary processing of forest products—logging, lumber and panel manufacture, pulping, and papermaking—is concentrated near abundant timber supplies, mostly softwoods in the South and Pacific Northwest. Secondary processing (manufacture into finished products) tends to take place close to markets.

The South is the major pulping region of the United States, accounting for two-thirds of production in 1976. The remaining production was about equally divided between the West (17 percent) and the North (14 percent). Sixty percent of secondary paper manufacture (converted paper products such as containers, bags, sanitary products, and stationery) is located near major markets in New England and the North Central and Middle Atlantic States.

Most lumber and panel manufacture occurs in the West and the South, where softwood timber is most available. The West accounts for more than two-thirds of lumber production, with the South producing most of the remaining one-third. The West also accounts for most panel production, although the South has gained rapidly since the early 1960's. Manufacture of panel products—e.g., waferboard and oriented strand board—is located in the North Central and Northeastern regions, and virtually all expansion is expected to occur in these regions.

Future Role of Forest Products

Most basic industries are in economic trouble as a result of high labor costs, foreign competition, aging plant equipment, low productivity, lagging innovation, and, in some cases, dwindling raw materials. The forest products industry is an exception. Although it was hit hard by the recent recession, conditions are favorable for the industry to enlarge its contribution to the domestic and international economy because:

- World demand for forest products is expected to grow in the decades to come, presenting U.S. firms with opportunities to develop new markets.
- Supplies of competitive products from some foreign countries are expected to decline, particularly in Southeast Asia.
- The U.S. timber supply picture is on the whole optimistic, with increased levels of timber production anticipated in the future. Many international competitors are confronted with tighter supplies.
- Most important timber production regions in the United States already have well-developed transportation and manufacturing facilities. Other countries (Brazil, the U.S.S.R., and Canada) have equal or greater timber supplies, but these are not as accessible or as easily exploitable.

Forest Resources

The United States ranks third among nations in exploitable forest area and first in industrial timber production (table 2). U.S. timber grows rapidly, especially in the South where financially mature softwoods can be grown in 30 to 40 years, compared with two to three times longer in many parts of Canada, the Soviet Union, and some parts of the Western United States. Transportation and manufacturing systems are well developed in many heavily forested regions of the country, unlike the U.S.S.R. and most of the developing nations, where roads, railroads, or water transportation systems must be built before interior forests can be harvested.

National timber supplies are likely to be sufficent to meet probable domestic wood demand for the foreseeable future, given current trends in intensive forest management (see ch. V). Beyond this, with increased forest productivity, the United States also can supply a larger share of world wood needs and meet unexpected domestic demand should it arise. There are many opportunities to expand timber supplies significantly through widespread use of existing intensive management technologies for growing, harvesting, and processing timber.

Forestland availability is not likely to become a serious limitation unless wood demand increases dramatically without adoption of technologies capable of increasing timber supplies and improving the efficiency of wood use (see

Table 2.—Countries With Largest Forested Areas

	Exploitable forest area (million ha)[a] [b]	Growing stock (million meters^3 over bark)[c]			Industrial harvest (billion ft^3) 1977
		Total	Coniferous	Broadleaved	
U.S.S.R.	389	74,710	62,000	12,710	10.0
Brazil	305	47,088	98	46,990	1.5
United States	195	20,132	12,906	7,226	11.5
Canada	191	19,645	15,571	4,074	5.1

[a] Exploitable forest definitions differ by country. Some countries such as Canada have restrictive definitions that result in conservative estimates of exploitable forestland. Volume estimates for the U.S.S.R. include growing stock on some 110 million acres (44.5 million ha) considered to be unproductive forestland.

[b] To convert hectares to acres, multiply by 2.471.

[c] To convert cubic meters to cubic feet, multiply by 35.31.

SOURCES: United Nations Food and Agricultural Organization, *Yearbook of Forest Products, 1979* (Rome, 1981); G. M. Bonner, *Canada's Forest Inventory 1981* (Environment Canada, 1982); United Nations Environment Program/Food and Agricultural Organization, *Los Recorsos Forestales de la American Tropical* (Rome, 1981); United Nations Economic Commission for Europe, *European Timber Trends and Prospects, 1950 to 2030* (Geneva, 1976); U.S. Department of Agriculture Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: 1982).

Photo credit: U.S. Forest Service

Intensive forest management can significantly expand U.S. timber supplies

ch. V and vol. II). **Nevertheless, several trends could affect future timber availability:**

- The U.S. **forestland base probably will shrink** in the future because of conversion for agriculture and development and because of allocation of additional Federal timberland to wilderness and other restricted uses.
- **Private nonindustrial forests (PNIFs) are not owned chiefly to produce timber income.** With the forest products industry owning only 14 percent of the timberlands, it will have to increasingly rely on PNIF lands for future resources. Timber supply in some areas could be reduced by demands for wildlife habitat, recreation, and amenities or for fuelwood.
- **Continued growth in residential fuelwood consumption could be a special concern, because it potentially could compete with the forest products industry for commercial wood supplies. Current fuelwood consumption has been several times higher than anticipated, but available information is not sufficient to determine the extent to which fuelwood may be depleting future timber reserves.**
- State-level survey data on forest acreage and timber inventories is collected infrequently, averaging once every 12 years. As a result, **data at the national level used by the Forest Service in its RPA assessments is based in part on estimated updates and therefore may reduce the accuracy of projected resource trends.**

Technological Opportunities To Extend Timber Resources

Trends in domestic timber growth are on the whole favorable, although less so for softwood species and the sizes of trees in highest demand. **U.S. timber inventories have been increasing for at least three decades, a reversal of an earlier trend towards decline** (see ch. VI). Growing stock on commercial forestland increased from 603 billion ft^3 in 1952 to 711 billion ft^3 in 1976. Net annual growth in 1976 was 21.6 billion ft^3 compared to 13.9 billion ft^3 in 1952. **Most of the increase has been in hardwood species,** which could afford major opportunities for expanded wood use for products and fuel. Hardwoods comprise about one-third of the growing stock inventory, but account for only about one-fourth of the national timber harvest.

Two-thirds of the inventory is in softwoods, which are preferred for many high-volume uses. **Softwood stock has increased slowly** due to greater demand and liquidation of old-growth timber in the West. Old-growth stands have enormous volumes of standing timber, but grow very slowly if at all; replacement stands have less volume and smaller trees but grow rapidly.

Existing technologies for growing, harvesting, and processing timber could significantly extend wood resources if widely adopted (see ch. V). Existing processing technologies are able to manufacture high-performance products from wood previously considered too small, unsuitable, or defective. This capability could increase the market for low-demand, less expensive hardwoods and permit the greater utilization of residual or defective materials now left on harvested sites.

The development of **harvesting technologies and systems capable of economically recovering previously wasted material in an environmentally sound manner could increase the amount of timber removed** from harvest sites and open some additional areas that are now off limits for environmental reasons. **Key needs include** the development of **small tract harvesting equipment** targeted to the needs of small landowners; **the training of woodsworkers** in productively efficient, safe, and environmentally sound harvesting operations; and **a systems approach to harvesting** to integrate the growing, harvesting, and manufacture of wood products. To date, the Federal Government generally has given harvesting technologies low priority in forestry R&D activities.

Opportunities exist to expand long-term timber supplies through intensive forest management systems (application of planned treatments to forestland to increase growth of industrial-quality timber). Compared to cropland, most U.S. forestland is managed well below the current state of the art of management technology, but this is consistent with forestry's historical role as a residual use of land. Despite the increase in inventories that has occurred in recent years, net growth averages only 60 percent of growth levels that could be achieved if all stands were stocked for optimal growth. Over time, **far greater growth rates could be achieved if harvested stands are replaced with rapidly growing, genetically improved seedlings managed under intensive silvicultural regimes.**

Intensive timber management is expensive, however, with costs of planting alone often exceeding $100 per acre. **Economic opportunities for timber management investments may exist on 139 million to 168 million acres in 25 States. The net annual growth increment (net growth attributable to management) could be 11 billion to 13 billion ft^3 annually if all these investments were made—at a cost of approximately $10 billion to $15 billion over the course of a rotation (30 to 50 years)** (see ch. V).

Land Use and Ownership Trends

Most forestland in the United States is not owned exclusively for timber production. It often is owned for various other purposes, including recreation, wildlife, or speculation. Of the 482 million acres of "commercial" forestland (forestland considered capable of supplying industrial timber on a sustained basis but not necessarily so used), 58 percent is owned by 7.8 million PNIF owners, most of whom are

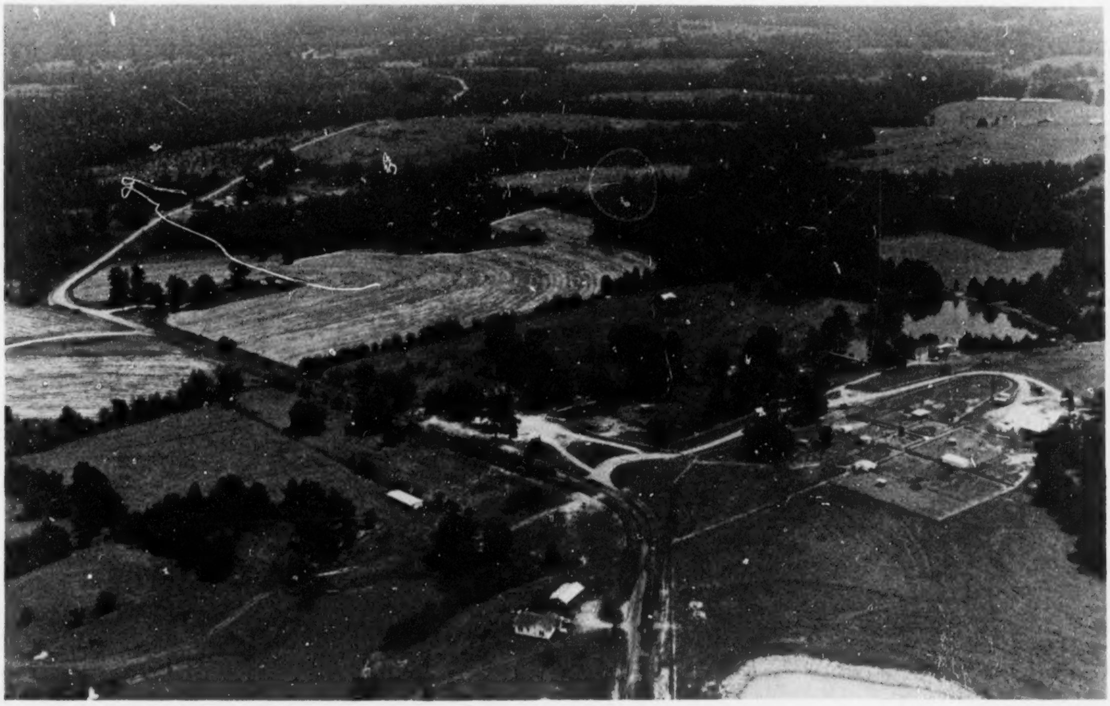


Photo credit: Soil Conservation Service

Much of the forestland in the Eastern United States is privately owned in small lots

not chiefly concerned with growing timber. **PNIF owners nevertheless contribute about 47 percent of all timber produced domestically and about 35 percent of the softwood timber. Their share is expected to increase significantly in coming decades.**

Twenty-eight percent of the commercial base is owned by public agencies, usually for multiple uses. The forest products industry owns the remaining 14 percent. **Industry lands contribute disproportionately more to supplies (over 30 percent in 1976) because they tend to be better suited to timber growing than other lands.**

According to the Forest Service, commercial acreage declined 5 percent between 1962 and 1977. **Most of the decline occurred on PNIF land and is attributed largely to diversion of forestland to agriculture and development.** Wilderness areas set aside on Federal lands accounted for approximately 30 percent of the decline, but **much of the land reserved as wilderness is not highly productive timberland** (see ch. VI).

Future forestland trends are difficult to foresee, but **the Forest Service anticipates that only modest declines in commercial forestland are expected** over the next 50 years, as agricultural pressures ease. But agricultural requirements probably will continue to exert a powerful influence on future forestland trends. **If farmland requirements expand,** as was the case in the 1970's, **greater declines in forest acreage may be expected, especially in the South,** which contains 20 million acres of forestland with crop potential. **If recent (1980-83) crop surpluses continue for a protracted period,** more land may revert to forest than is cleared for agriculture. If so, **new opportunities may arise to establish managed plantations on unneeded cropland,** as was the case in the late 1950's and early 1960's.

Ownership patterns could complicate the development of timber resources, due to the small size of many private holdings and the diverse objectives of their owners. **Over 20 percent of all private forestland is in tracts of 100 acres** or less—a size generally too small to capture fully economies of scale in management and harvesting (see ch. VI). Most PNIF land is now owned by nonfarmers, some of whom have little interest in timber production. Owners of large PNIF tracts may be investors interested in timber management, although data to substantiate this is fragmentary. The most promising PNIF lands for intensified management are the larger tracts in important timber production areas.

Forest industry holdings are expected to increase only modestly in the future, but these may be some of the most cost-effective lands for investing in timber management. A key factor that makes industry and some nonindustrial private lands prime areas for increased timber productivity is continuity of ownership. Other factors that make forestry investments on these lands attractive are their large tract size, high natural productivity, proximity to processing facilities, and the commitment of their owners to grow timber.

Public and Private Sector Involvement in Timber Resource Development

The Federal Government owns about one-fifth of the Nation's commercial timberland and has established several programs to encourage timber management on private lands. Federal lands available for timber production are managed under a multiple-use sustained-yield framework established by statute by the Congress. Temporary increases in harvest levels are permitted in some limited circumstances, but changes in existing law probably would be needed to significantly increase harvest levels beyond those included in current Federal planning. Over the long-term, intensive management of Federal lands could increase growth greatly on land available for timber production, but this would require increases in the Forest Service budget to upgrade timber management and to ensure careful attention to impacts on other multiple-use resources.

Forest management activities on private lands are encouraged by a variety of Federal and State programs related to cooperative fire, pest, and insect control programs; research, education, and technical assistance; and financial assistance through tax incentives and direct cost-sharing of management practices with small landowners. Capital gains taxation of timber income is perhaps the greatest single Federal inducement for timber management, although it does not require landowners to use tax savings on management. Several USDA agencies in addition to the Forest Service, including the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, and the Cooperative Extension Service, play roles in providing assistance to forestland owners.

Since the early 1970's, several State governments have expanded their forestry assistance programs. Many States offer preferential tax laws for forest owners, and a few provide limited cost-sharing assistance, either to supplement Federal funds or on an independent basis. Some States are developing State forest plans to establish overall goals for forestry activities and have integrated forest products into their overall industrial development plans. Most States also have forest practices acts, providing guidelines or, in some cases, regulations for harvesting and reforestation.

Because of limited Federal and State budgets, however, private sector interests will be pivotal in determining future levels of management on private nonindustrial lands. Fortunately, a number of forest products firms sponsor landowner assistance programs aimed at the PNIF owner, and efforts of this kind may warrant expansion if government funds are cut back. Private financial institutions recently have begun offering limited partnerships and other arrangements to attract investors to forestland management opportunities. Although this trend is too recent to be assessed adequately, it could be an important future source of capital for upgrading timber management.

Domestic Production and International Trade

The U.S. forest products industry is the most productive in the world. In 1980, the United States ranked first in paper and paperboard, industrial roundwood, nontropical hardwood lumber, plywood, pulpwood, and chip production, and second in softwood lumber production (table 3). Several factors make this leadership possible. Although the United States has only about half of the exploitable forestland that the Soviet Union has, its forests are far more productive due to more favorable climate, terrain, and soils. U.S. forests generally are more accessible than those of most other nations, and the forest products manufacturing capacity of the United States is unsurpassed. The United States also has an enormous demand for forest products, with consumption expected to increase. However, there seems to be no reason that increased domestic consumption would significantly limit U.S. exports of forest products. American forests can support much larger harvests, and technologies capable of increasing timber productivity and manufacturing efficiency are available. Therefore, **the United States is well positioned to satisfy both domestic and a major share of future global forest product requirements** (see ch. III).

By taking advantage of existing opportunities, the United States probably can become a net exporter of forest products before 1990. The United States is currently a net importer of forest products, but during the last 20 years its exports have grown much faster than its imports. This trend probably will persist. It is likely, however, that Canadian wood products will continue to account for large portions of U.S. consumption. Canada's lower production costs, good transportation systems, and nearby softwood forests give Canadian producers an advantage in providing lower grade softwood lumber, woodpulp, and newsprint for Americans. Continued use of these Canadian products increases the opportunities for U.S. producers to export forest products where the U.S. competitive edge is greatest—in paper, panels, hardwood products, and high-quality softwood lumber (see ch. III).

Domestic Demand for Forest Products

The high productive capacity of the U.S. forest products industry has emerged in response to substantial domestic demands. **The United States is the world's number one consumer of most industrial wood products.** Per capita consumption of lumber, panels, paper, and paperboard in North America is greater than in any other region of the world. The United States consumes almost 25 percent more paper and paperboard per capita than Sweden, which ranks second in per capita use.

U.S. consumption of forest products averaged 12 billion to 13 billion ft^3 per year in the past decade, growing slowly from 8 billion ft^3 at the beginning of the 20th century. About three-quarters of this consumption consisted of softwoods, which are used for most lumber and panels and many types of paper.

Domestic consumption of forest products is expected to nearly double by 2030, according to the Forest Service (see box A). While U.S. forests are capable of supporting much larger harvests than they currently do, a 1980 Forest Service analysis projects that this in-

Table 3.—Major World Producers of Selected Wood Products

	Industrial roundwood	Sawn softwood	Sawn hardwood	Plywood	Pulpwood and chips[a]	Paper and board
United States	308	58	17	16	109	57
U.S.S.R.	278	87	12	2	38	9
Canada	156	41	—	2	39	13
Sweden	49	—	—	—	26	6
Finland	44	—	—	—	19	6
Japan	—	31	6	8	—	18
People's Republic of China[b]	—	13	8	—	—	5
Brazil	—	—	6	—	—	3
Korea	—	—	—	2	—	2

[a] Pulp production figures are in millions of metric tons. All other products are in million cubic meters.

SOURCES: FAO Yearbook, 1980; National Forest Products Association and the U.S. Foreign Agricultural Service, *Wood for the World, Today and Tomorrow*, n.d.; and M. Bayliss, L. Haas, and S. Reid, "Basically Good Production But a Weak Economy Marked 1980 Record," *Pulp and Paper* (August 1981), p. 67.

Box A.—Timber Demand and Supply

Figures for future timber supply and demand used in this report differ from some of the figures cited in the Forest Service 1980 projections because the Forest Service prepares two different forecasts. One is called the equilibrium level forecast (cited in this report), and the other the base level forecast.

The base level forecast assumes that timber prices will continue to rise at the same rates as in the past (1950 to 1976) and projects timber demand and supply at these assumed prices. Because projected timber demand rises faster than projected supply, these forecasts show a gap between demand and supply (see table below). As a result, the base level forecasting technique is often referred to as the "gap model."

The equilibrium level forecast projects what could happen in a free competitive economy, where the interaction of buyers and sellers determines timber prices. Under equilibrium level forecasts, therefore, demand and supply are the same, and timber price is allowed to increase in order to achieve this equality.

Comparison of Base Level and Equilibrium Forecasts, 2030

	Base level (billion ft^3)	Equilibrium level (billion ft^3)
Timber demand	28.3	25.5
Timber supply	24.4	25.5
Domestic	21.2	23.0
Imports	4.5	3.8
Exports	1.3	1.3
Gap	3.9	0.0

SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), pp. xxi, 203, 211.

crease in consumption will have significant adverse effects on the economy and the environment as timber becomes more scarce. **OTA found, however, that there is reason to doubt that the Forest Service projections are accurate.** More than likely, Forest Service forecasts of timber demand are overstated. Future domestic demand for wood products probably will grow, but it is unlikely to reach the projected levels unless there is a major upturn in the housing market or government intervention to stimulate wood fuel use (see ch. IV). Conversely, the Forest Service forecasts of timber supply are conservative, particularly on forest industry lands, and probably underestimate the ability and willingness of landowners to increase timber production. However, recent data indicate that softwoods on nonindustrial private ownerships are likely to be in shorter supply in the South before 2000 due to a shortfall in softwood reforestation. In addition, the **Forest Service projections probably understate the ability of technology to stretch U.S. wood supplies.** There are many technologies currently available that can improve wood utilization in the forest, in the mill, and in end use.

During the next few decades, the consumption of forest products is expected to grow. As demand rises, increasing pressure on the forest resource probably will bring an increase in stumpage prices, and this, in turn, may motivate landowners and the industry to invest more money in intensive timber management and more efficient facilities. Should these changes occur, they could result in the greater availability of forest products at reasonable prices and the increased competitiveness of

U.S. wood products on world markets. Many industrial and nonindustrial private owners already are making substantial investments in intensive timber management, and the forest industry is upgrading the efficiency of its plants and equipment.

U.S. Imports of Forest Products

While the United States is the world's top producer of forest products, it is also one of the largest importers. The majority of U.S. imports are from Canada and consist mainly of lower grade softwood lumber, woodpulp, and newsprint (see ch. III). In 1981, the value of imports from Canada totaled over $7 billion and accounted for over two-thirds of U.S. imports of wood products. The United States also imports substantial amounts of tropical hardwood veneer and plywood from the Far East.

The United States and Canada are mutually dependent for forest products. Canada's share of U.S. lumber markets has grown steadily for over 30 years and currently accounts for nearly one-third of U.S. lumber consumption. In 1981, the United States consumed approximately two-thirds of Canada's production of softwood lumber, pulp, paper, and paperboard. Although Canada imports smaller quantities of wood products than does the United States (about 1 billion dollars' worth in 1981), the United States is its major foreign source.

Current exchange rates between U.S. and Canadian currencies favor Canadian exports. The Canadian dollar is worth about 0.8 $U.S., making Canadian products more attractive to American consumers. Although Canadian wood manufacturing costs are rising faster than those in the United States, a situation which may offset some of Canada's advantage in the future, **imports of wood products from Canada are likely to continue to account for significant portions of U.S. consumption.**

U.S. Exports of Forest Products

Imports of Canadian lumber and newsprint to offset some increases in domestic demand, combined with the productive capacity of the U.S. forest products industry, probably will enable the United States to expand its forest products exports. Although the United States still has a balance-of-payments deficit in wood products trade, the deficit has narrowed in the past decade. In 1982, the United States was a net exporter of solid wood products. Overall, U.S. producers have an unprecedented opportunity to expand their exports for three reasons. First, world demand for forest products, particularly paper, is expected to grow rapidly, possibly increasing by 50 percent by 2000 according to some estimates. Second, at the same time, many countries that have been traditional sources of wood products are unable to expand production significantly because of raw materials limits and lack of installed manufacturing capacity; some regions may even face declining production before the turn of the century. Third, North American producers have both the manufacturing capacity and access to productive forests and skilled labor that could enable them to expand production and capture a growing share of world markets. **U.S. forest products can be manufactured at costs that are competitive throughout the world, an advantage that is probably sustainable for the foreseeable future.**

However, other factors diminish the competitive position of the United States in world markets. The most important of these are global economic and financial conditions (see ch. III). The recent world recession adversely affected U.S. exporters in general, including the forest products industry, which in 1982 experienced a decline in exports from 1981 levels. Spurring the decline was the increased strength of the U.S. dollar relative to other currencies. The U.S. balance-of-payments deficit would have been expected to cause some devaluation of the dollar, but this adjustment has not occurred, primarily because of the enormous Eurodollar market and high U.S. interest rates.

Tariffs, quotas, and nontariff barriers also depress offshore markets for U.S. forest products. **Nontariff barriers probably are the most important.** The most deleterious nontariff barriers affecting U.S. forest products exports currently are product standards, nontariff charges or taxes on imports, preferential trade agreements, and discriminatory ocean freight rates. In the future, preferential trade agreements may have an even greater impact on the ability of U.S. producers to maintain and penetrate world markets. Countertrade, a form of barter between nations, may be particularly troublesome unless the U.S. Government or producers also are willing to engage in countertrade agreements.

Future Potential

The latest assessment required by RPA was prepared by the Forest Service in 1980. Because it projected domestic wood demand to increase more rapidly than timber supply, the 1980 assessment forecasted that timber will become more expensive relative to other products. Although this future is possible, it may not be the most probable. Forest Service demand projections are likely to be overstated, and timber supply adjustments that would be expected as a result of increasing timber consumption are not given adequate consideration.

In the 1980 assessment, the Forest Service concluded that increased efforts to expand timber production and increase manufacturing efficiency may be needed to meet domestic needs. OTA has concluded that domestic needs probably can be met without major changes in policies affecting timber production. **However, it appears that there may be unprecedented opportunities for U.S. producers to expand forest products exports in the next few decades as well as satisfying domestic needs** (see ch. IV).

Future Domestic Demand

Forest Service projections of future timber demand are based largely on projections of overall economic growth and demographic shifts. Future demand for all forest products except those used in housing is tied to a projection of future economic growth, while forecasts of forest products used in new home construction are prepared independently by the Forest Service.

Forest Service estimates of future timber needs for housing are probably too optimistic. Its estimates of future housing replacement are much higher than historical levels, and the effects of increased housing prices are not given adequate emphasis. Housing size may rise more slowly than forecasted, or it may stabilize or decrease in the future. Also, multifamily units, manufactured housing, and mobile homes may become more desirable, particularly if housing does not become more affordable. The Forest Service recently has revised its housing forecasts downward in recognition of some of these factors.

Although projected wood needs for housing have been reduced, Forest Service forecasts of timber demand have not changed significantly, probably due to increased projection of demand for fuelwood. This increase in fuelwood demand offsets declines in softwood demand resulting from lowered projected housing forecasts. These projections show fuelwood demand roughly quadrupling by 2020, from over 40 million cords to 180 million cords per year, primarily for industrial power generation.[1] This projection is based on scanty data and short-term trends that probably should be regarded as tentative.

Forest Service forecasts of demand for other forest products generally are linked to the gross national product, which is projected to increase by 2.0 to 3.7 percent in the future. While this rate of growth is consistent with historical trends, it may change appreciably if the economy undergoes structural reorganization (e.g., decreased activity in some basic industries and increased activity in high-technology and service sectors). Forest Service forecasts provide no information about the possible effect of different rates of economic growth on timber demand, nor is there detailed analysis of factors that affect wood products use other than demographic shifts and economic activity. For example, expanding use of electronic communication and data processing may have significant impacts on future amounts and types of paper used, although it is difficult to predict either the magnitude or the direction of likely long-term changes.

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[1] These projections are contained in U.S. Department of Agriculture, Forest Service, "America's Renewable Resources: A Supplement to the 1979 Assessment of the Forest and Rangeland Situation in the United States," review draft, Feb. 4, 1983. The draft report does not specify what proportion of the increase is attributable to residential, commercial, or industrial uses.

Future Domestic Supply

Forest Service forecasts of future timber supply probably underestimate the productivity of U.S. forests, particularly if timber prices rise (see ch. IV). This underestimate is primarily a result of failure to include the effects of improved technology and more intensive timber management on future timber supply.

However, the 1980 assessment probably overestimates future softwood timber growth on private nonindustrial land in the South, due mainly to a shortfall in softwood reforestation during the last 20 years. Even with increasing timber management intensity, southern softwoods may be scarcer than projections show, beginning in the 1990's. Conversely, softwood supplies in the Pacific Northwest may be somewhat more abundant than the 1980 assessment shows, according to more recent timber survey information, although not enough to offset the likely reduction in southern softwood supply, assuming no increase in timber management intensity.

Forest conditions can change significantly between Forest Service State surveys, which are usually conducted every 10 to 15 years, or every 12 years on the average. Outdated survey information is a continuing problem for timber resource forecasters. There are, however, other uncertainties in timber supply forecasting. **The manner in which the Forest Service treats these uncertainties probably leads to conservative forecasts of future timber supply** (see ch. IV). There are two sources of bias in the supply forecasts—conservative assumptions about future timber management intensity and conservative assumptions about the ability of technology to stretch the wood resource.

Short-run supply curves show that even large increases in stumpage prices produce only modest increases in timber harvest. This type of increase is reasonable, because timber crops usually require three or more decades to mature. In the long run, however, there are many adjustments that probably would be made in response to increased stumpage prices.

One result of increased stumpage prices probably would be increased levels of forest management. As timber values increase, a broader range of investments in timber production is economically possible, and it is likely that these investments will be made, particularly on forest industry lands. The 1980 assessment assumes no increase in timber management intensity for the next 50 years, even with rapidly rising stumpage prices. (Alternative projections showing the effect of increasing levels of management intensity have been made, but they have not been given adequate attention.) Even under the current stumpage price structure, increased investment in intensive forest management is occurring.

The role of changing technology in stretching the wood resource also is treated conservatively in the 1980 assessment. A variety of technologies is currently available that can increase manufacturing efficiency as well as promote conservation in end uses (see vol. II). Investments in more efficient manufacturing are being made by the forest industry, and rising stumpage prices are likely to increase the use of these technologies. More efficient manufacture is a key factor in keeping forest product prices from increasing at the same rate that stumpage prices increase.

Opportunities To Expand Exports

U.S. producers have an opportunity to significantly expand exports of forest products, particularly paper. This opportunity is emerging because world demand for forest products is growing, possibly increasing by 50 percent by 2000. Also, many traditional world timber supply regions are not capable of expanding production to meet this demand—some may even face declining production as a result of deforestation. Furthermore, the United States has a large, modern, efficient manufacturing capacity, forests that can support larger harvests, and access to skilled labor and materials.

The value of U.S. forest products exports has more than quadrupled in the last 20 years, while the value of imports has almost doubled (see ch. III). Although the United States consistently has been a net importer of forest products, the trade deficit has declined. This is primarily due to increased exports of woodpulp and paper products, export of high-value products and imports of lower value products, and, in the last few years, decreased lumber imports. Lumber imports probably will rise as the U.S. economy and homebuilding industry recover from recession. International economic recovery, which is likely to parallel that of the United States, probably will mean expanded international markets for U.S. forest products.

Most of the increased consumption of forest products is likely to come from industrialized nations, particularly Western Europe and Japan. Both are already major purchasers of U.S. woodpulp and paper products and probably will buy more in the future. This is because Scandinavia, which supplies large quantities of paper to Western Europe, is facing limits on its forest resource as well as rising pulpwood costs and may be unable to compete with less expensive U.S. paper products, such as linerboard. Also, Japan imports large numbers of logs from Southeast Asia to make paper and other products, but harvest rates in Southeast Asia may not be sustainable through 2000. A cooperative effort between the Foreign Agricultural Service (FAS) and the National Forest Products Association (NFPA) is underway to promote exports of U.S. lumber and panel products to fill these developing needs.

There are several trade barriers that limit the ability of U.S. producers to expand wood products exports. The most important of these are world economic and financial conditions. For several years, global recession has dampened demand for wood while the dollar has remained strong relative to other currencies due to its enormous stocks in Eurodollar markets and high U.S. interest rates. Improvements in these conditions undoubtedly would stimulate U.S. wood exports in spite of other trade barriers.

Trade barriers limit U.S. exports of processed wood products, but not raw materials. The United States probably will have no trouble exporting logs, chips, and pulp in the future, but will need to seek reductions of barriers on processed lumber, panels, and paper products. FAS and NFPA are cooperating in negotiations with foreign producers and governments to reduce tariff and nontariff barriers affecting lumber and panels. Part of this effort is devoted to market promotion, primarily to gain wider acceptance of U.S. homebuilding techniques in order to stimulate demand for American building products.

Lumber and panels are often specialty products, but most U.S. papers are commodities on world markets. Reduction of tariffs on paper products such as linerboard could stimulate U.S. paper exports, particularly in Western Europe, although Scandinavian producers already have free access to these markets due to lower tariffs. While both the Foreign Commercial Service of the Department of Commerce and FAS are authorized to—and do—provide assistance to the U.S. paper industry in easing trade barriers, specific efforts comparable to the FAS/NFPA initiative in solid wood products do not exist.

Policy Considerations

Federal policies toward forestry and the forest products industry are found in numerous laws that authorize programs and expenditures within the Departments of Agriculture, Interior, Commerce, and Treasury, and within the independent Environmental Protection Agency, Office of the U.S. Trade Representative, and TVA. General statutes, such as the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190), Wilderness Act of 1964 (Public Law 88-577), Clean Air Act (42 U.S.C. 7401 et seq.), the Clean Water Act (33 U.S.C. 1251 et seq.), and others, also affect timber production. State timber policies often are patterned after Federal statutes.

The Federal laws that most directly affect long-term forest management are the Forest and Rangeland Renewable Resources Planning Act (RPA) and its amendment, the National Forest Management Act (NFMA). These statutes are the basis for formulating policies affecting the timber supply, R&D, and the National Forest System.

National Goals

Although RPA and NFMA direct the Forest Service to prepare a comprehensive assessment every 10 years and a national program every 5 years, the acts provide no clearly stated long-term goals to guide the Forest Service in policy development. In this vacuum, the program and the Forest Service's annual report have become the basis for budget requests and appropriations.

Under NFMA, the Forest Service concentrates heavily on National Forest System policy and programs. In the absence of congressional guidance, however, the Forest Service tends to provide little analysis of policies and programs that it does not specifically administer or that do not pertain to the National Forest System, although there is no limitation on its authority to do so. This emphasis does not address the roles of other Federal and State agencies and the private sector in national timber production.

Thus, while the Forest Service is responsible for overseeing the Nation's wood future, it concentrates primarily on land and forest management. Little attention is given to those economic factors that affect the business practices of the forest products industry.

There have been a number of proposals by private groups that Congress establish a national timber production policy. Proponents of better defined goals note that RPA has enabled the Forest Service to assemble a comprehensive data base on U.S. timber resources and future demand, but RPA does not provide congressional guidance for national strategic planning. RPA's focus on Forest Service programs tends to be of limited use to the private sector and the States, reducing it to little more than a budget justification for Federal activities.

With 10 years of RPA data available, Congress has a great deal of reliable information on which to base decisions on the future role of wood in the U.S. economy. In considering an overall national industrial policy, Congress may wish to foster and promote the forest products industry. Among U.S. basic industries, it is the only one* that has a sustainable resource base; adequate, modern, and efficient plant capacity; expanding international markets; and a competitive edge over most other exporting nations.

U.S. Timber Supply

National timber famines have been predicted repeatedly since the turn of the century. None has occurred to the extent that the national economy has suffered appreciably. While there have been regional migrations by the forest products industry as certain types of timber have been depleted, major shortages have been avoided through changing technologies, economic adjustments, substitution of other materials, increased production in other regions, and imports. Government programs, such as organized fire protection, also have helped.

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*U.S. agriculture shares many of the same advantages, but is not considered an industrial sector.

The Forest Service's 1980 RPA assessment, like forecasts of the past, anticipates increasing timber scarcity in the future. Major uncertainties are inherent in these projections, however, particularly in their assumptions about future economic conditions, consumer demand (especially housing), timber growth, and technological change.

Because timber demand-supply forecasts continue to be more an art than a science, wide ranges in future timber resource and consumption estimates should be expected. Timber assessment models may be used most effectively in showing how changes in future conditions affect wood demand and supply and in identifying those factors most critical to policy decisions. By generating alternative scenarios based on different economic and resource assumptions, the Forest Service projections could aid Congress in more fully analyzing a variety of options. The majority of the analysis in the 1980 assessment, however, is based only on one scenario.

International Trade

To benefit from opportunities to export its goods, the forest products industry will have to mount a concerted effort to expand foreign trade. In the past, U.S. firms have concentrated on the vast domestic wood market, with their interest in offshore markets picking up only when U.S. demand slackened. As a result, the U.S. forest products industry has gained international notoriety as a somewhat unreliable supplier. This reputation will have to improve if the U.S. industry is to take full advantage of foreign markets. This change already has started. The solid wood sector of the industry and FAS recently began working on foreign market development and trade barrier reduction.

While the private sector has primary responsibility for export market development, the Federal Government must ensure that as few trade barriers as possible exist between the United States and potential importing nations. Although the U.S. forest products industry is in a strong competitive position internationally, protective tariffs and nontariff trade barriers put U.S. forest products at a disadvantage in a number of major consuming countries. This situation is not unique to forest products, but if U.S. industry is to successfully maintain and penetrate major foreign markets, it will be necessary to overcome these impediments.

Of all forest products, the United States is probably competitively strongest in pulp and paper. Markets for high-strength paper (linerboard) for shipping containers are expected to expand rapidly, and U.S. industry has the current capacity and future potential for supplying them. At the moment, however, FAS is not promoting paper products as actively as it is solid wood products. The Foreign Commercial Service also is authorized to undertake export promotion, but its promotional activities for forest products are minimal.

In 1982, Congress passed the Export Trading Company Act (Public Law 97-290) that authorized the creation of overseas export trading companies with exemptions from certain provisions of the antitrust and banking laws. Currently, the Department of Justice is formulating regulations to govern the operation of these companies. The Japanese have had outstanding success with this concept. Whether U.S. firms can duplicate the Japanese experience will partially depend on how the Justice Department structures its regulations and how skillfully the U.S. industry uses trading companies to expand foreign markets.

Research and Development

Government, academia, and the private sector share responsibility for conducting forestry research. Traditionally, the Federal Government has played a major part. In general, the

Government concentrates on funding basic research and performing R&D functions of a long-term, high-risk nature that are unlikely to be undertaken by the forest products industry in response to market forces. This strong Government involvement is based on the premise that a large portion of the wood-using industry and forestland owners represent small, diverse units with limited capital and knowledge and that the results of such research generally would benefit this group.

Under RPA, the Forest Service has set priorities for research activities. Over 70 percent of the recommended Forest Service R&D budget is devoted to growing, protecting, and inventorying trees. Less than 3 percent is aimed at harvesting technologies, yet, as OTA has concluded in this study, improved harvesting technologies offer important opportunities for stretching the Nation's timber supply.

The forest products industry appears to lag behind other basic industries in research expenditures. It is difficult, however, to obtain reliable data on forest firms' R&D investments because of the proprietary nature of this information. In addition, related industries, such as forestry equipment suppliers, also do some R&D to benefit their customers, but data is unavailable. Antitrust fears undoubtedly have limited joint research programs. There are indications that the Justice Department is becoming more lenient toward cooperative industrial research efforts, but in the absence of clarifying language in the antitrust statutes, the forest products industry is unlikely to move more aggressively.

Private Nonindustrial Timber Management

Private nonindustrial forests account for 58 percent of the commercial timberland base and supplies about 47 percent of industrial roundwood. These lands, 90 percent of which are located in the East, are accumulating timber inventories—especially hardwoods—at a rapid rate. Timber supplied from PNIF lands is expected to increase significantly, both in volume and as a proportion of total national timber supplies.

At the moment, limited Federal assistance in the form of tax benefits and direct cost-sharing for management expenditures is available to PNIF owners. A key issue in U.S. forest policy is whether the public interest would be served by additional incentives for intensive timber management on private holdings or whether this should be the responsibility of the private sector. The Forest Service and the forest products industry estimate that, over the next few decades, investments of between $6 billion and $9 billion in forest management may be needed on PNIF lands to meet future wood demands. There are cogent arguments both for and against extensive public support of such investments.

Those opposed to extensive government involvement in private timber management note that private nonindustrial landowners already provide a major portion of U.S. timber supplies and that prospects for further increases are good, provided management is upgraded. If demand does not rise rapidly, they say, the cost effectiveness of public incentives for private timber management is questionable. If demand does rise quickly, they claim, the attractiveness of timber management investments will be increasingly recognized by the private sector and investments will follow in response to the market.

Those favoring more government involvement assert that PNIF landowners may be unable or unwilling to assume all the risks involved in timber management and that broader public objectives (e.g., the national commitment to affordable housing) justify substantial Federal commitment to ensuring an available supply of softwood in the next 50 years. Since investments must be made decades in advance of demand, proponents of extensive government programs say that current public decisions on assistance should provide for investing more heavily in intensive timber management to prepare for future timber requirements.

Government involvement in private nonindustrial forestry is not limited to financial assistance for management. A variety of research, education, extension, and technical assistance programs have been authorized by Congress in the past to assist private landowners. While the Forest Service leads in assistance to State and private forestry, on-the-ground delivery of forestry assistance is a cooperative effort between several USDA agencies, State forestry agencies, county agricultural stabilization committees, and soil and water conservation districts.

State and private forestry programs entail a broad range of objectives and concerns, including noncommodity and nonmarket values of importance to both landowners and the public. For this reason, it is difficult to separate the commodity production profit motive from that of land stewardship that benefits the public at large. Thus, forestry assistance is traditionally less commodity-oriented than is agricultural policy.

Since the early 1970's, Congress has enacted several laws to boost private nonindustrial forestry. These include the Forestry Incentives Program (Public Law 93-86), passed in 1974, and the Cooperative Forestry Assistance Act (Public Law 95-313), the Forest and Rangeland Renewable Resources Research Act (Public Law 95-307), and the Renewable Resources Extension Act (Public Law 95-306), all passed in 1978.

Although budgetary constraints have limited the implementation of these laws, the current forestry assistance policy framework focuses more on commodity aspects of private forestland management through:

- Increased emphasis on renewable resource research, technology transfer, and expanded extension services to private nonindustrial forestry. Although funded modestly, these efforts in time could result in more rapid on-the-ground implementation of research findings in much the same way as agricultural research findings have been disseminated effectively to farmers.
- Changes in the tax law that ease inheritance tax burdens on forest land owners and provide favorable treatment of reforestation expenses on a limited basis.
- Potential establishment of crop insurance programs. In 1980, through the Federal Crop Insurance Act (Public Law 96-365), Congress authorized the Federal Crop Insurance Corporation to develop, in cooperation with the Forest Service, an all-risk insurance program for timber crops on a pilot project basis. The pilot program, expected to be launched in late 1983, will cover pine species in selected southern counties. It is similar to other agricultural crop insurance programs.

A major problem in government landowner assistance is how to target the limited funds available to those lands with the highest potential for cost-effective management. Tracts of less than 100 acres often are too small to capture economies of scale in timber management, yet 47 percent of the acres treated with Federal forestry incentive cost-sharing assistance in 1979 were in tracts of 40 acres or less.

As a result of its assessment, OTA identified a range of congressional options to deal with all of the major issues discussed in this chapter (table 4) and in greater detail in chapter II.

Table 4.—Summary of Policy Considerations

Option	Action required	Impact of option
Policy Issue A: Establishing objectives for the management and use of the Nation's forest resources		
1. Create a commission to recommend a series of objectives for national timber production for congressional adoption	Establish a committee representing timber, recreation, wildlife, range, water, and consumer interests	Would provide recommendations to Congress as a basis for establishing national timber production goals and objectives and a benchmark for timber management appropriations
2. Formulate congressional objectives for national timber production	Amend the Forest and Rangeland Renewable Resources Planning Act	Would provide targets for USDA's Forest Service to develop programs for timber production, provide guidance for other Federal agencies to achieve national goals, and help the private sector integrate its activities with Government action
3. Direct the administration to formulate specific long-range goals for the Nation's forests, including a comprehensive approach to link the resources of government and the private sector	Administrative action by *all* relevant agencies to implement national goals established by Congress	Would extend Government planninf for timber production and forest products trade to *all* relevant agencies, not just the Forest Service
Policy Issue B: Encouraging research, development, and transfer of forestry-related technologies		
1. Require periodic assessment of the Forest Service R&D Program for congressional review	Amend the Forest and Rangeland Renewable Resources Research Act of 1978	Would enable Congress to evaluate the Federal research budget with respect to national timber production objectives
2. Direct the administration to issue rules, regulations, and guidelines to exempt joint research among private firms from antitrust laws	Issue adminstrative rules, regulations, and guidelines	Would permit private firms to participate in joint research ventures aimed at implementing national timber production and wood products trade objectives
3. Direct USDA to place greater emphasis on forestry technology transfer under the framework provided by the Forest and Rangeland Renewable Resources Research Act, the Renewable Resources Extension Act, and the Cooperative Forestry Assistance Act	Greater funding for Cooperative Extension Service forestry activities, and technology transfer functions of the Forest Service	Would accelerate on-the-ground implementation of recent research findings and technological developments through the education, information, and demonstration services provided by the cooperative extension system, and the Forest Service
4. Establish two or three centers of excellence at universities to focus on improved utilization of wood and wood materials	Legislation creating the regional research centers	Would provide R&D support for improving wood materials
5. Allocate more research funds to the effects of intensified forest management (including harvesting technology) on the environment, soil nutrient levels, wildlife, and other resources	Greater funding of environmental components of the Forest and Rangeland Renewable Resources Research Act related to timber management and harvesting	Would facilitate development of environmentally sound management practices, and provide a better information base about environmental effects of silvicultural activities
Policy Issue C: Enhancing the role of the United States in international trade of wood products		
1. Clearly establish the authority, responsibility and capacity in USDA's Foreign Agricultural Service (FAS) or the Commerce Department's Foreign Commercial Service (FCS) to assist the private sector in developing international markets and removing foreign trade barriers in paper products	Administrative directives or legislative action to assign responsibility and provide for assisting in export of paper products	Would provide assistance to the U.S. pulp and paper industry in expanding exports of paper products (FAS is already responsible for promotion of solid wood products)
2. Direct the U.S. Trade Representative to give priority to identification and negotiation of reductions of tariffs and quotas that restrict U.S. exports of forest products	Congressional directive which may require legislative action or statutory amendments	Would focus the trade representatives' attention on export problems of the U.S. forest products industry

Table 4.—Summary of Policy Considerations (continued)

Option	Action required	Impact of option
3. Direct the administration to improve recordkeeping and statistics on tariffs, quotas, and other barriers affecting international trade in U.S. forest products	Administrative action to upgrade statistical collection and reporting of trade statistics and identification of trade barriers	Would systematically identify and report on existing and developing barriers to U.S. forest products
4. Assign responsibility to a specific agency in the Departments of Agriculture or Commerce to monitor the performance of export trading companies with respect to wood products and recommend needed changes in the legislation or regulations	Congressional directive or legislative amendment, followed by administrative action	Would enable Congress to evaluate the effectiveness of the Export Trading Company Act in strengthening the U.S. position in international trade in wood products
Policy Issue D: Improving RPA information for formulating forest policy		
1. Direct the Secretary of Agriculture to give priority to forest inventories in important timber producing States, and to establish priority schedules for inventorying important regions	Congressional directive and administrative action, including budget adjustments	Would provide timely information in States with large and changing inventories, thereby improving the data base for Forest Service projections and timber management programs and budgets
2. Direct the Secretary of Agriculture to improve the coordination of the RPA and RCA planning processes among agencies of USDA	Congressional directive or amendments to the RPA and RCA	Would ensure that uniform treatment and emphasis is given to forestlands by agencies of USDA in planning documents
3. Direct USDA to expand its efforts to monitor fuelwood use and landownership patterns at regional and National levels to improve the reliability of RPA data	Congressional directive and administrative action	Would provide information about the consumption and impact of fuelwood removals and landownership changes on the timber resource and implications of these trends for public policy
4. Direct the Forest Service to provide alternative projections of future timber supply and demand as part of the RPA planning process, and identify the impacts of changes in key variables on demand, supply, and price	Congressional directive and administrative action	Would provide Congress with information that reflects a range of possible futures on which to formulate policies, rather than single-point estimates or "most-likely scenarios" as is now the case
Policy Issue E: Identifying timber management needs		
1. Direct the Forest Service to place greater emphasis on hardwood management opportunities	Congressional directive and administrative action to emphasize intermediate stand treatment and hardwood silviculture	Would provide for incremental gains in timber quality and quantity on private lands without major expenditures required for intensive management or species conversion. Would provide information needed to "target" public and private assistance to those lands most suitable for intensive management in cost-effective fashion
2. Direct USDA to undertake a "potential forestland study" to identify extent of marginal, erosive, or reverting agricultural land that may be better suited for timber production than crop or other agricultural uses	Congressional directive and administrative action	Would provide better information for formulation of national policies related to agriculture, conservation and forestry assistance on private lands
Policy Issue F: Establishing public and private management priorities		
1. Direct the Department of Treasury, in cooperation with the Forest Service, to report to Congress on effectiveness of current tax treatments in encouraging timber management	Congressional directive to the Secretary of the Treasury, and possible amendments to the Internal Revenue Code	Would establish the extent to which the current tax system supports timber management investments, and would assess impacts, costs, and desirability of alternative systems

Table 4.—Summary of Policy Considerations (continued)

Option	Action required	Impact of option
on private lands, and on alternative strategies (e.g., tax credits to replace capital gains treatment of timber income and tax incentives to industry to expand private forestry incentive programs)		
2. Emphasize Federal assistance programs related to research, education, extension, and technical assistance associated with private nonindustrial forestry	Appropriations to the Forest Service, the Extension Service, the Soil Conservation Service, and other agencies providing forestry related information, education, and technical assistance to private owners	Would place increased emphasis on programs of broad application, leaving the private sector to determine financial investment requirements
3. Focus Federal cost-sharing for tree planting to agricultural land that should be retired from production for a protracted period due to erosion; relinquish most other cost-sharing assistance to the private sector	New legislation or amendments to the Cooperative Forestry Assistance Act, and the Soil Conservation and Domestic Allotment Act of 1936	Would channel limited Federal funds for cost-sharing to areas where timber production would serve multiple public objectives such as erosion prevention and water pollution control
4. If general cost-sharing is maintained, direct the Secretary of Agriculture to focus Government cost-sharing programs on those private lands whose potential for producing timber is greatest	Congressional directive and/or legislative amendments to the Cooperative Forestry Assistance Act and the Soil Conservation and Domestic Allotment Act of 1936	Would ensure that Government investments be made in lands best suited for efficient timber production, and that such investments will contribute to future timber supply
5. Direct the administration to intensify timber management on suitable Federal lands	Increased appropriations and congressional directives	Would accelerate timber growth on suitable Federal lands and increase future yields
6. Investigate alternative timber management and timber sales procedures for Federal lands which would provide industry with incentives to assure increased responsibility for intensive management	Congressional hearings and deliberations, leading to possible legislative enactments and associated administrative action	Would transfer more responsibility for Federal timberland management to the private sector, subject to Federal guidelines, policies, and planning requirements

SOURCE: Office of Technology Assessment.

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CHAPTER II

Policy Analysis and Legislative Options

Introduction

U.S. forest policy has changed dramatically since the turn of the century. To counteract the destructive exploitation of the Nation's forests that resulted from the "cut-out and get-out" logging practices of the 1800's, the Federal Government began setting aside forest preserves of uncut timber that later formed the nucleus of what is now the National Forest System. Since then, Federal and State Governments also have become instrumental in conservation programs aimed at improving the management of private forests. Since World War II, the forest products industry in particular has assumed increasing responsibility for promoting, advancing, and practicing sound timber management. The private sector's initiative in developing the Nation's timber resources has thrust it into a position of leadership in expanding the contribution of forest products to the American economy.

Nevertheless, despite the private sector's ascendance, Federal and State forest policies continue to focus primarily on timber management and secondarily on economic issues crucial to the forest products industry beyond those related to timber supply. Several Federal Government departments and agencies administer programs dealing with resource utilization, employment, environmental quality, transportation, housing, finance, and international trade, all of which directly and indirectly affect the forest products industry. Nationally, the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (Public Law 93-378) and its amendment, the National Forest Management Act (NFMA) of 1976 (Public Law 94-585), now address timber management objectives in a broad multiresource framework. RPA and NFMA, however, concentrate on land management—as Congress intended—and deal mainly with the U.S. Department of Agriculture's (USDA) Forest Service programs and responsibilities. As a result, the broader role of forest products in the Nation's economy and in its industrial base continues to receive attention in a piecemeal, incidental, and uncoordinated manner.

Possible Congressional Strategies

Two excellent positions—the favorable outlook for domestic timber supplies and the U.S.'s strong potential for increased world trade in wood—together give Congress a range of legislative alternatives for revising forest policies. Congress may choose from among four general strategies to:

1. Relinquish responsibility for national timber supplies and industry development to the private sector to meet domestic demands so that little government involvement and no special incentives are needed. It is assumed that timber supplies are adequate and probably will remain so. This strategy would require modification of portions of RPA that authorize projections of timber supply and demand, reductions in Forest Service program levels, and no special Federal emphasis on increasing forest products exports. Timber management on Federal lands would revert to its status before the enactment of the NFMA, and the market would determine private investments in timber management and plant expansion.
2. Maintain the status quo, accepting current limitations and uncertainties concerning

information in RPA, and make no special effort to induce expansion of the forest products industry beyond present program levels. Under this strategy, ongoing efforts for timber management on Federal and private lands would continue, possibly with incremental changes, but would not be broadened or significantly changed.

3. Continue to rely on the planning process established by RPA as the general guide for Federal policy, but upgrade the information base, forest inventory, and timber inventory to support the development of a wider range of program alternatives and program plans.
4. Identify national goals for developing forest resources to take advantage of future international markets by:
   - improving RPA as indicated in Strategy #3 above,
   - providing aggressive Federal support to the forest products industry in its efforts to expand its role in world markets, and
   - expanding U.S. timber supplies through increased support of research and technical assistance to private forestry and through intensified management of Federal lands.

The degree of congressional action and Federal involvement increases from Strategy #1, which would dismantle the current Forest Service planning system and return to the former decentralized management system, to Strategy #4, which would require more positive Federal support and commitment to expanding U.S. timber potential and increasing international trade in forest products.

The magnitude of the economic and social impacts of a national strategy to strengthen and expand the U.S. role in world trade of forest products is difficult to forecast accurately, but the direction of such changes can be anticipated. Significant expansion of forest production, improved wood utilization, and modernization of old mills and construction of new efficient plants probably would bring increased prices for forest products in the short run. In the long run, however, higher prices could stimulate more investment in efficient manufacturing, forest management, and research than would be undertaken under the existing price structure. As producers shift to more efficient production facilities and more intensive management and harvesting practices, forest product prices could be forced downward. The effects of price increases on consumers is often slight. Wood products in general account for less than 15 percent of the price of the average home, with structural lumber and panels in particular accounting for only 7 percent.[1] The same is true for many other consumer goods—wood is often only a small portion of the price.

The forest products industry currently employs about 1.7 percent of the full-time labor force. Expanding production to meet world demand for forest products could increase employment in the industry. The increase may be modest, however, because modern mills are becoming less labor-intensive as the industry moves toward mechanized technologies. Also, employment in the solid wood (lumber and panel) products sector is subject to wide swings, since production depends on the cyclical homebuilding industry. Increased participation in world markets possibly could cushion this oscillation somewhat, but, as international economies become more closely linked through commerce and banking, so have worldwide economic trends. An expanded U.S. forest products industry role in world trade may not significantly buffer its employees from the shocks of recurring recession. Increased international trade could result in better price stability for forest products prices, which often dramatically increase as production attempts to meet pent up demand during economic recoveries.

Expanded production could have environmental effects, too. Some observers say that expanded export markets could result in "exporting" the Nation's soil, fisheries, and wildlife as well as forest products if good forest practices are not adhered to. If not conducted properly, timber harvesting and intensive forest management often may change wildlife habitats, affect the availability of forage for livestock, cause erosion, and decrease water quality. Shorter rotations and greater utilization of forest residue may deplete soil nutrients over an extended period of time that could possibly affect future productivity of forest sites. Some timber management practices are incompatible with some forms of outdoor recreation. While severe environmental damage can be avoided in increased management intensity and residue utilization, some negative effects probably are inevitable.

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[1] U.S. Congress, Congressional Budget Office, "Forest Timber Sales: Their Effect on Wood Product Prices," background paper, May 1980.

In summary, a program to increase the role of U.S. forest products in international trade may:

- increase the supply of timber available to U.S. producers as well as international markets,
- result in slightly higher employment in the forest products industry,
- increase the U.S. role as an exporter of forest products, thus improving the balance of trade,
- slightly increase the price of housing and other consumer products whose production depends on forest products, and
- cause some deterioration in the environmental quality of U.S. forests.

Policy Issues

Discussed below are six policy issues. Under each are presented key findings, a brief summary of current policy status, and selected legislative options for congressional consideration.

Policy Issue A

Establishing Goals for the Management and Use of the Nation's Forest Resources

There are no clearly stated long-term national goals to guide Federal and State Governments and the private sector in long-range planning for the use and management of the Nation's forests.

Findings

- RPA, as amended in 1976 (NFMA), does not set forth general long-range **national** goals for timber production; it does not require the executive branch to develop specific national goals, except for the National Forest System.
- In the absence of specific national goals, the RPA planning process lacks a reference point for program revision (required by the act every 5 years) and fails to measure success in improving the use of the Nation's forest resources.
- In addition to the U.S. Department of Agriculture, (USDA) numerous Federal departments and agencies and State and private institutions play important roles in national programs to improve the management and use of the Nation's forests. Among these agencies and institutions are those that deal with finance, housing, environmental quality, international trade, and resource management. Clear national goals are needed to guide these institutions in providing support for USDA.

Current Policy Status

The framework for national long-range forest resources planning is based on two statutes, RPA of 1974 and a 1976 amendment to RPA, NFMA.

RPA directs the Secretary of Agriculture to prepare a comprehensive assessment of renewable resources through 2030, including timber, range, water, fish, wildlife, outdoor recreation, and wilderness, and to update it every 10 years. The Secretary also is directed to formulate a program based on the assessment recommending levels of Forest Service activities and to update it every 5 years. The assessment and program serve as guides for Forest Service planning and aid in the development of annual budget proposals. Once accepted by Congress, the program becomes the basis for Forest Service annual reports that accompany the President's budget submissions to Congress. Each annual report includes a quantitative and qualitative appraisal of how the administration's proposed budget meets the needs of the program. If the budget does not support the policy objectives or activity levels that the program prescribes, the President is directed to specify the reasons for proposing different policies or cutting programs. NFMA establishes an elaborate planning process for the National Forest System.

In sum, RPA as amended directs the Secretary of Agriculture to make an assessment of the present and future state of the Nation's forest resources and to formulate a program accordingly. However, Congress has not provided specific goals to be used in carrying out this directive. The original RPA contained neither a statement of policy nor congressional findings. Findings set forth by NFMA and more recent policies stated in the Forest Service's 1982 Annual Report are very broad and fail to provide clear direction for implementation of RPA's mandate.

In the absence of congressional guidance, the Forest Service has interpreted RPA program requirements narrowly by focusing on National Forest System planning and Forest Service programs. This emphasis has obscured the potential role of other Government agencies and of non-Federal lands, which comprise about 80 percent of the Nation's commercial forest, in meeting future U.S. economic and social needs. In addition, little attention is given to public policies that may affect the private sector's ability to compete in world markets, obtain capital to develop timber resources, and develop more efficient forest management and wood production techniques.

In short, the business of increasing the Nation's ability to maximize benefits from its immense endowment of timber resources transcends the Forest Service, yet the responsibility for assessing and planning for these resources is assigned largely to that agency. If the Forest Service is to take the lead in advancing U.S. timber production, it must go beyond Federal resource management activities and concern itself with the broader economic issues facing the forest products industry, as well as with social issues that could arise.

As a result of RPA, the Forest Service has both an extensive forest resource data base and the capacity to project future timber needs. The next logical step is to use this information to formulate a national strategy for maximizing potential domestic and world trade benefits afforded by the U.S. economic position and forest resource endowment.

A variety of organizations have proposed goal-setting to foster increased timber production from U.S. forests. In 1980, the Forest Industries Council recommended establishment of "a national timber productivity goal" aimed at reducing consumer costs and building a trade surplus in wood products. Similarly, a recent conference sponsored by the American Forestry Association and 23 other organizations proposed a "national goal for timber," including numerical goals for fiber production to be set through the RPA process.

Congressional Options

Several options are available to Congress should it determine that national timber production goals are desirable to promote domestic economic, social, and international trade development. It could:

1. Create a commission to recommend goals for adoption by Congress as U.S. policy for the management, use, and economic contribution of the Nation's forests.
2. Formulate clear congressional goals for incorporation into RPA.
3. Direct the administration to formulate specific long-range goals for the Nation's forests, including a comprehensive approach to link the resources of government and the private sector.

Policy Issue B

Encouraging Research, Development, and Transfer of Forestry-Related Technology

Improved harvesting systems could increase the amount of timber recovered from the Nation's forests.

Findings

- Research and development (R&D) in harvesting systems offer great potential for immediately increasing the amount of wood available to the forest products industry.
- Nearly 100 percent of the wood brought into modern mills is utilized, either for products or energy, but many old mills currently do not achieve optimal use of materials. As existing mills are replaced with technologically advanced facilities, further improvements in product yields and energy efficiency are probable, even though overall utilization of raw materials cannot increase appreciably.
- Expanded research in the utilization of hardwoods and defective timber could further extend U.S. wood supplies.
- Additional basic research in wood chemistry, structure, and mechanical and engineering properties could increase wood's long-term competitive position relative to other materials.
- Prior research in silviculture, forest management, and wood utilization has provided an abundance of on-the-shelf technologies, but many have not been applied extensively in practice. Economic factors, resistance to change, and capital limitations are some of the barriers that limit commercialization of new technologies. The technology transfer system for forestry research is not well developed when compared to agriculture, although a basic framework to achieve this was established by Congress in 1978.
- The forest products industry lags behind other basic industries when its R&D funding is compared to sales volume and output value.
- Inadequate consideration has been given to recent significant increases in the use of wood fuel and their impacts on traditional wood products, existing timber stands, and future silvicultural practices.

Current Policy Status

Responsibility for forestry and wood products R&D is shared by Federal and State Governments, academia, and the private sector. Lines of responsibility are often blurred, however, and one sector's role is not separated from another. Public agencies and academia generally undertake basic and applied research, although industry does a considerable amount of basic research as well. Public agencies venture into developmental areas where broad social gains may be realized and the development is long term, high risk, and unlikely to attract private research investment. Sometimes public agencies undertake applied R&D when the commercial sector consists of small enterprises without technical and funding capacity or when R&D will benefit "public goods" such as wildlife or recreation.

A major barrier to improved R&D cooperation among companies are antitrust statutes. While antitrust laws permit joint research ventures that are approved and monitored by the Department of Justice, many firms are wary of working with competitors for fear of subsequently being judged in restraint of trade. The pulp and paper sector is particularly hesitant to join research ventures because of the spate of antitrust suits brought against some major producers in the past. While firms in some industries—such as electronics—have joined successfully in research consortia, uncertainties about Justice Department interpretation continue to dampen industries' enthusiasm for cooperative R&D.

The 1980 RPA assessment proposed $196 million for R&D planning for the fiscal year 1984 Forest Service budget. Forty-four percent of the funding would be directed toward growing and protecting timber, 27 percent toward inventory and economic research, 14 percent toward forest products utilization, and less than 3 percent toward harvesting and engineering. The remaining 12 percent would be distributed among recreation, fish and wildlife, watershed management, and surface environment. While appropriations for Forest Service R&D have been much lower than the RPA target, funding apportionment has followed RPA recommendations closely. In recent years, Forest Service research budgets have declined from $112 million in fiscal year 1982 to $105 million in fiscal year 1983. A budget of $101 million is requested for fiscal year 1984.

The Forest Service research budget clearly emphasizes growing, protecting, and inventorying trees (71 percent of the proposed RPA R&D budget). While silviculture, management, and forest protection are important means to increase timber production, improved harvesting systems may provide the greatest immediate payoff in extending the Nation's timber supply. The RPA assessment seems to underestimate the potential gains from harvesting and engineering R&D and recommends that it comprise only 2.8 percent of the Forest Service research budget.

In 1976, an estimated 1.4 billion cubic feet (ft^3) of usable wood residues were left in the forest after logging, plus an additional 3 billion to 6 billion ft^3 of tops, branches, and defective timber. These unused residues constitute approximately one-fourth to one-half of the volume harvested. Wood on other sites remains unused because the land is too environmentally sensitive to harvest with existing technology and must be discounted from the national timber base. Approximately 185,000 acres of the National Forest System in the Pacific Northwest are in this category. Additional acreage may be excluded because it is not economically feasible to harvest.

Improved harvesting systems could facilitate the economical harvest of small tracts and the removal of small logs. Manufacturing technologies continue to advance, and previously unusable wood materials and tree species now can be turned into products or used for energy.

Historically, harvest system development in the United States has been isolated from R&D efforts aimed at growing timber and processing forest products and has not been adequately supported by either private or public funding. In contrast, Western European and Scandinavian countries have developed innovative harvesting technology as a result of well-funded efforts coordinated among the public and private sectors.

In the absence of a comprehensive R&D program, the United States has focused largely on individual machines rather than on integrated harvesting systems designed to fit the timber resource, harvesting requirements, and manufacturing processes. Private sector efforts primarily have taken place by trial and error, in small job shops, and by adaptation of agricultural equipment. Increased research on the environmental impacts of harvesting can help guide the future development of machinery and harvesting systems. Research on wildlife impacts and possible effects on soil nutrient levels may be especially critical in the design of systems that remove most woody biomass from sites.

Technology transfer is an important but often overlooked component of public R&D programs. Transfer of forestry technology has received less attention than it has in agriculture where new innovations are implemented rapidly by farmers through the information, education, and demonstration programs of the Cooperative Extension Service. The extension system also is used to disseminate forestry research findings, but with comparatively little funding.

In 1978, Congress strengthened the framework for forestry technology transfer by enacting three laws to further the general policies and direction set by RPA—the Cooperative Forestry Assistance Act (Public Law 95-313), the Forest and Rangeland Renewable Resources Research Act (Public Law 95-307), and the Renewable Resources Extension Act (Public Law 95-306).

These statutes were intended to give technology transfer and forestry extension higher priority within USDA structure and among State and local agencies involved with forestry and agriculture. The laws emphasize rapid communication of forestry research and technological information through USDA channels and through upgrading of Federal assistance to State and county extension agencies. Funding has been at a low level, however. The Renewable Resources Extension Program, for example, was authorized at $15 million annually, but initial funding of $2 million was not provided to the Cooperative Extension Service until fiscal year 1982 and it has been cut from the administration's proposed fiscal year 1984 budget. A small amount of general-purpose cooperative extension funds is used for forestry activities.

Congressional Options

Should Congress determine that further action to encourage R&D and transfer of forestry technology is desirable, various options are available. Congress could:

1. Amend either the Forest and Rangeland Renewable Resources Research Act or RPA to require periodic assessment of the Forest Service R&D program for congressional review.
2. Direct the administration to issue regulations and guidelines to expressly permit joint research efforts among firms without interference from antitrust restrictions.
3. Direct the Secretary of Agriculture to place greater emphasis on forestry technology transfer under the framework provided by the Forest and Rangeland Renewable Resources Research Act, the Renewable Resources Extension Act, and the Cooperative Forestry Assistance Act.
4. Establish two or three national research centers of excellence aimed at improved utilization of wood and wood materials. The laboratories could be located at universities with strong supporting departments and could emphasize collaborative research among academia, industry, and government.
5. Allocate more funds to the examination of the effects of intensified forest management (including harvesting technology) on the environment, soil nutrient levels, wildlife, and other resources.

Policy Issue C

Enhancing the Role of the United States in International Trade of Wood Products

The United States has an opportunity to expand its exports of solid wood and paper products, but a number of trade barriers must be eliminated or eased if the U.S. wood products industry is to successfully increase its share of world trade.

Findings

- Rapidly growing global demand and the comparative advantage of U.S. producers give the United States a unique opportunity to expand its role as a supplier of forest products to world markets. The U.S. advantage is particularly great in pulp and paper.
- The character of world trade is changing, and many of the changes place U.S. producers of all goods and services at a disadvantage. The growing use by many countries of nontariff trade barriers and foreign government assistance to exporters are detrimental to U.S. exporters of pulp and paper and solid wood products. Although their use has declined over the past three decades, many traditional quotas and tariffs remain, and these also hinder U.S. exporters.
- World economic conditions also have eroded the advantages of U.S. products. In particular, the recent global recession and the strength of the dollar relative to other currencies have adversely affected U.S. exports.
- Many importing nations see the U.S. solid wood sector of the forest products industry as an unreliable supplier because of its tendency to lose interest in foreign markets when domestic recessions abate.
- Foreign perception of the United States as an unreliable trading partner is reinforced by the U.S. Government's use of trade sanctions and embargoes as a foreign policy weapon.

- Tariffs, quotas, and nontariff barriers inhibit the increased export of pulp and paper and solid wood products, but nontariff barriers probably are the most damaging.

Current Policy Status

The United Nations Food and Agriculture Organization (FAO) projects that world demand for industrial forest products could be 50-percent higher by the end of the century. The United States is one of only a few nations that is well positioned to satisfy this demand, but its ability to do so is hampered by a number of factors, ranging from monetary and foreign policies of the Federal Government to product standards. While the commitment to expand international markets for U.S. wood products must come primarily from the forest products industry, there are a number of ways the Government may assist the private sector.

The forest products industry is one of few basic industries with a sustainable competitive advantantage over foreign producers. While the domestic steel and automotive industries have lost their edge in international markets to Western European and Japanese producers, U.S. wood and paper products are becoming more competitive. There are several reasons for this:

- U.S. producers can tap abundant renewable sources of wood that are cheaper than those of most other nations;
- the U.S. wood products industry enjoys lower production costs than most foreign firms due to lower energy costs, available skilled labor, and advances in energy efficiency; and
- U.S. manufacturing capacity and access to forests are well developed, in contrast to many competitors with remote forests.

However, the ability of the U.S. forest products industry to exploit this advantage is limited by world economic conditions, domestic government policies, past industry behavior, and trade barriers, including tariffs, quotas, and nontariff impediments. The most severe and least controllable limitations are worldwide recessions and the strength of the dollar relative to foreign currencies. The U.S. Government's past use of trade sanctions and embargoes as instruments of foreign policy also has tended to undermine world confidence in the United States as a reliable dealer. Few of these factors affect forest products any more than they do other exports, but in some cases tariffs, quotas, and nontariff barriers specifically reduce the competitiveness of the forest industry.

The U.S. solid wood products sector is considered a rather fickle trader by many foreign customers. Historically, U.S. suppliers have tended to lose interest in foreign buyers when domestic demand for lumber and panels increases. While the sector is becoming more aggressive in developing foreign markets for solid wood products, the strength of its commitment during a sustained economic recovery remains untested.

The removal or reduction of tariffs, quotas, and nontariff barriers could provide a long-term stimulus for U.S. forest products exports. Although tariffs and traditional quotas have been reduced since the formation of the General Agreement on Tariffs and Trade (GATT), many barriers remain. Nearly every major country that imports U.S. wood products levies tariffs or quotas, but these almost always affect processed products more than raw materials. Without tariff and quota reductions, the United States can expand exports of logs, woodpulp, and rough lumber, but similar expansion of finished lumber, panel products, and paper exports may be more limited.

Negotiation of tariffs and quotas is dealt with in GATT by the U.S. Trade Representative. Increasingly, GATT negotiations have focused on nontariff barriers, too, but GATT codes on these barriers are often vague and difficult to enforce. Nontariff barriers, however, may be a more potent deterrent to increased U.S. wood products exports than tariffs and quotas. Reduction of nontariff barriers probably can be handled best through bilateral negotiations with specific nations or trading associations and will require both government and industry involvement. The National Forest Products Association recently began a cooperative effort with the USDA Foreign Agricultural Service

(FAS) to improve market acceptance and reduce trade barriers for U.S. lumber and panel products. There is no comparable program for pulp and paper products, although both FAS and the Department of Commerce's Foreign Commercial Service are permitted to provide this assistance.

The formation of export trading companies, authorized by the Export Trading Company Act of 1982 (Public Law 97-290), may improve the competitive position of the U.S. forest products industry in international markets. The act allows certain exemptions from antitrust law to permit American firms, including banks, to band together to export overseas. Some west coast forest products firms have expressed interest in forming export trading companies, but whether U.S. producers will be able to duplicate the success of the Japanese is unknown.

Congressional Options

Several options are available to Congress should it determine that expansion of U.S. wood products exports is in the national interest. It could:

1. Clearly establish authority, responsibility, and capacity within FAS or the Foreign Commercial Service to assist the private sector in market development and reduction of nontariff barriers to trade in pulp and paper products.
2. Direct the U.S. Trade Representative to give high priority to identifying and negotiating reductions in tariffs and quotas that most severely limit increased U.S. exports of wood products.
3. Direct the FAS, Foreign Commercial Service, Forest Service, or other agency to maintain current information on tariffs, quotas, and nontariff barriers affecting trade in wood products.
4. Direct the Forest Service, FAS, Foreign Commercial Service, or other agency to monitor the effect of regulations under the Export Trading Company Act and to identify legislative changes needed to make U.S. wood products export trading companies competitive in world markets.

Policy Issue D
Improving RPA Information for Formulating Forest Policy

The formulation of forest policy requires up-to-date national level information about forest acreage, inventories, and growth trends and realistic assumptions about future demands. Improvement in the current system for projecting timber supply and demand is needed if decisionmakers are to have adequate information for the design and funding of timber management programs and assistance to private landowners.

Findings

- More frequent inventories are needed if timely, reliable forest information is to be provided to Congress in RPA assessments. Each State is surveyed on the average of once each 12 years, but in some important timber-producing States the survey cycle is longer. As a result, national information is based substantially on estimates rather than actual, up-to-date field data.
- Inventories and growth trends for U.S. forests may be different in reality than those shown in the 1980 RPA assessment because of outdated survey information. Past national assessments consistently have underestimated growth and inventories, both in the national aggregate and on a per-acre basis. Uncertainties surround current and projected growth trends and inventories in the 1980 RPA assessment. In some regions and for some tree species, estimates may be overstated; in others, understated.
- A major uncertainty concerns the revival and rapid increase of wood used for fuel—especially for residential home heating. The phenomenon is so recent that adequate data on consumption, sources, and trends is lacking. Recent Forest Service and Department of Energy surveys indicate that residential fuelwood use increased several times more rapidly in the late 1970's than was anticipated. The proportion of fuelwood that came from industrially important growing stock is not clear.
- Several trends in landownership patterns may affect future timber production. Farm-

ers own a declining proportion of the forestland base, while "miscellaneous" private owners are increasing in numbers. Less than 30 percent of the private forestland has been held by the same owner for 30 years or more. Also, about one-fifth of all private forests is in parcels that are economically less efficient to manage. Ownership data is improving, but significant gaps remain, especially in the South where much of the private forestland is located.

- Better information about the on-the-ground effectiveness of USDA private landowner assistance is needed to evaluate Government policies and assess agency programs. Several USDA programs are oriented toward farmers, who own a declining proportion of the forestland base.
- Forest Service projections of timber supply and demand may overstate the future scarcity of timber. These projections are made using survey data and extrapolations of past timber growth, landowner behavior, and the relationship of demand for wood products to general levels of economic activity and population. More complete analysis of the sensitivity of these projections to changes in key variables is needed for Congress to evaluate proposed Forest Service timber management programs and budgets.

Current Policy Status

The collection and compilation of forest resource information has been a continuing function of the Forest Service since 1928, through congressionally authorized cooperative forest surveys in all States. Information requirements have increased in recent years due to the passage of RPA.

Through the Forest and Rangeland Renewable Resources Research Act, Congress explicitly acknowledged the need to "ensure adequate data and scientific information" in the development of RPA assessments. It directed the Secretary of Agriculture to "make and keep current a comprehensive survey and analysis of the present and prospective conditions of and requirements for renewable resources of the forests and rangelands of the United States . . . ."

Provision of up-to-date national forestland statistics and identification of trends are perplexing problems for the Forest Service because of the timing of State surveys. Forest surveys are statistically reliable, but they are conducted only periodically and irregularly in many States. As a result, the 1980 RPA assessment was based in part on adjusted field data, since 22 State surveys were compiled before 1970. Scheduling of forest surveys accelerated temporarily after the 1978 Research Act, but recent budget cutbacks have again slowed the inventory schedule.

Up-to-date survey information is crucial, especially in States where non-Federal lands make an important contribution to timber supplies, particularly in the South and the East. Private forestlands comprise 72 percent of the commercial forestland base and 80 percent of timber supplies and are expected to play an increasingly important role in future forest production. Most of this land is not owned by the forest products industry, and is subject to greater fluctuation in use and ownership than are public and industrial lands. The RPA estimates that, between 1962 and 1977, private nonindustrial lands declined by 26 million acres and forest industry holdings increased by 7 million acres. The net decline in private lands was 19 million acres. In some States, State and county lands also play an important role, particularly in the North Central and Northeastern regions.

Better land ownership data could assist in formulating and evaluating the effectiveness of forest resource policy. The Forest Service obtained national and regional information about forestland owners incidentally from a 1978 USDA rural land ownership survey, but the study was not aimed at forest owners and, as a consequence, provided insufficient information on owner motives and financial capability. As a result, comprehensive ownership data is available from only 11 Northeastern and Middle Atlantic States where the Forest Service has undertaken detailed surveys. While ownership information has improved, critical gaps remain, particularly in parts of the South where nonindustrial lands predominate.

Upgraded information about wood fuel use also is needed, since it now accounts for more than half of the wood consumed in the United States. The forest products industry burns about two-thirds, obtained primarily from manufacturing byproducts such as residues and pulping liquors. However, use of residential fuelwood has increased dramatically and now amounts annually to over 40 million oven-dry tons. Much of this tonnage probably comes from industrially inconsequential sources, although data is fragmentary. If fuelwood use continues to grow, however, consumers could compete with industrial markets in some areas, unless steps are taken to integrate wood fuel use into forest management and industrial wood systems.

Because of the overriding importance of non-Federal lands, closer coordination and greater consistency are needed between the RPA assessment process and a parallel USDA assessment and program conducted under the Soil and Water Resource Conservation Act (RCA) of 1978 (Public Law 95-192). RCA is limited to non-Federal lands and is oriented towards agricultural activities, but private forestlands are included under both RPA and RCA. Moreover, some key elements of Federal landowner assistance programs are provided by agricultural agencies such as the Soil Conservation Service, the Agricultural Conservation and Stabilization Service, and the Cooperative Extension Service.

Because of the recent origin of the RPA and RCA processes, it is not surprising that inconsistencies in their initial assessments have occurred. The Forest Service and the Soil Conservation Service have different missions and therefore different orientations and purposes in compiling forestland information. However, estimates of non-Federal forestland provided to Congress in the 1980 RPA assessment and the initial RCA assessment differed by tens of millions of acres—a discrepancy too big to be ignored. Most of this discrepancy is attributable to different land classification systems used by the two agencies, but some of it probably reflects the timing of field surveys—all of the Soil Conservation Service data was collected during 1976-77, when only part of the Forest Service data was current. USDA plans to use common non-Federal forestland figures in future assessments, and the two agencies are working to resolve the discrepancy.

Forest Service planning and budget requests for timber management programs on public and private lands are affected by projections of future need for wood. The most recent Forest Service projection made in the late 1970's shows increasing scarcity of timber in the next 50 years. This forecast is based partly on outdated (or adjusted) survey information, extrapolations of past trends in landowner behavior and timber management, and a wide range of assumptions regarding future economic conditions that are subject to significant change, particularly over the long time periods used in the forecast. Some analysts argue that these projections overestimate demand largely as a result of assumed high demand for housing and an overstatement of the gross national product growth. Timber growth trends are uncertain. Budget requests based on these projections may, as a result, place undue emphasis on timber management. Because it is difficult to forecast future demand and supply with any accuracy, projections based on a single set of assumptions are of limited value.

Congressional Options

Several options are available to the Congress if it decides that improved information is needed for policy formulation. It could:

1. Direct the Secretary of Agriculture to schedule State forest surveys to ensure that current information is available in key forestry States (those with a predominance of timber and changing conditions) for RPA assessments. Direct the responsible USDA agencies to identify options and costs for updating information on forestland conditions prior to production of an RPA assessment.
2. Direct the Secretary of Agriculture to identify and evaluate options for coordinating

and improving consistency of RCA and RPA assessments and programs affecting non-Federal forestland.

3. Direct USDA to expand its efforts to monitor fuelwood use and landownership patterns at regional and national levels to improve the reliability of RPA data.
4. Direct the Forest Service to provide alternative projections of future timber supply and demand and to identify the effects of changes in key variables on projected timber demand, supply, and prices.

Policy Issue E
Identifying Timber Management Needs

U.S. timber supplies can meet probable demand for forest products through 2030 if current management trends continue. Application of existing management technologies could increase timber growth far beyond current levels, but institutional, technical, and financial barriers must be overcome first.

Findings

- Timber harvest levels 50 percent greater than those of the high-demand period of the 1970's can be sustained for several decades without major changes in existing management technologies for growing, harvesting, and processing wood according to Forest Service base-level supply projections.
- While timber growth presently is increasing at a steady rate, other factors could significantly alter the future supply situation. One factor is wood fuel consumption, which recently has risen dramatically, although current data is inadequate to assess the implications for industrial timber supplies. Another factor is forestland conversion to nontimber uses. Most acreage losses have been on private lands as a result of shifts to agricultural and urban uses. USDA statistics vary significantly as to the exact magnitude of the shift. Wilderness set-asides on Federal lands have contributed somewhat to the decline in commercially available timberland, but wilderness areas generally consist of less productive, inaccessible sites, so that economically exploitable timber volumes are small in relation to the acreage removed from production.
- Timber management practices applied today will not have an appreciable effect on timber supplies until after 2010. Management proposals to reduce projected scarcities will require capital investments in the range of $10 billion to $15 billion over a 50-year period, mostly for softwood reforestation on private nonindustrial lands.
- In the absence of production goals for U.S. forestry, the need for investments of this magnitude is not well established. Forest Service models of long-range timber demand and supply predict increasing timber scarcities, particularly for softwoods, but the models use liberal demand assumptions and conservative supply assumptions. Uncertainty about future wood demand is a major constraint to private investment and casts doubt, too, on the need for public expenditure.
- Management programs to increase softwood supplies may need to be reevaluated so that less costly alternatives (e.g., improved management of existing hardwoods) receive more consideration for private nonindustrial forest (PNIF) lands.

Current Policy Status

Increasing the productivity of U.S. forests has been the major purpose of forest policy for nearly 80 years. Fears of possible timber famine have not panned out, in part because of the success of public programs and private initiatives to conserve supplies, reduce the hazards of fire, insects, and disease, and improve the utilization and management of forestland. U.S. forestland today provides more wood for industrial use than that of any other nation, even though the United States ranks third in exploitable growing stock.

The domestic timber supply situation has improved dramatically over time. It probably will continue to improve, affording opportunities to expand the contribution of U.S. forests to the economy. Growth trends are highly favorable for greater production, even assuming the continuation of present management practices. Increased timber harvests over the current level of about 13 billion ft^3 per year are biologically possible on a sustained basis. Net annual roundwood growth, now over 20 billion ft^3, has been increasing since 1952, although this is expected to taper off in the decades to come unless appropriate management practices intervene. Standing inventories are increasing rapidly, from 600 billion ft^3 in 1952 to 711 billion ft^3 in 1976, and are expected to continue to increase. Supplies of preferred species, especially high-quality softwoods, are tighter, however, and there are important regional differences.

Technological advances also favor increased production and have contributed to the improved timber supply situation. More efficient manufacturing processes have broadened the range of usable materials to include less valuable and underutilized species such as low-grade hardwoods and have enhanced the prospects for use of "nongrowing stock materials" (timber not counted in the standing inventories cited above). In addition, developments in harvesting technology have improved recovery of materials previously left on harvest sites, although comparatively low levels of R&D have hindered progress toward integrated harvesting systems.

Although timber supply prospects are on the whole optimistic, there are some important caveats. For example, residential fuelwood consumption skyrocketed during the 1970's. Most fuelwood is thought to come from sources that are not important to the industry, but high levels of fuelwood removal for a protracted period could tighten industrial supplies if appropriate management strategies are not adopted. Commercial forest acreage has declined recently, mainly because of the conversion of forestland to agriculture and developmental uses; continued decline is anticipated. Moreover, PNIF land, on which the industry increasingly depends for supplies, typically is not owned primarily for timber production, and some of this land is in parcels too small to benefit from "economies of scale" in management and harvest.

Management technologies applied to U.S. forests could greatly increase growth, but this is a long-term proposition because of the long growing cycle of trees. Most of the 482 million acres of commercial forestland in the United States is not managed primarily for timber growth; intensive timber management (application of planned treatments to forestland to increase production of industrial roundwood) is increasing but it is not widely applied.

Because tree crops take at least 30 years to grow, investment decisions must be made several decades before harvest amid uncertainty about future timber markets and the future state of technology. Intensive timber management opportunities currently identified by the Forest Service were sought in response to projections of increased timber scarcity (primarily softwoods) over the next 50 years.

To reduce the projected scarcity, "economic opportunities for management intensification," or lands where investments would yield 4 to 10 percent or more in constant 1977 dollars, have been identified on 30 to 35 percent of the commercial forestland base. These opportunities will be expensive to take advantage of because they would require a total investment of $10 billion to $15 billion over a 30- to 50-year period, but they could increase growth significantly on treated lands 30 to 50 years from now. Nearly all of the identified opportunities involve reforestation or conversion of hardwood timber stands to softwood, mostly on PNIF lands.

Shifts of land between agriculture and forestry are important but difficult to assess in terms of acreage available for timber management. During the 1970's, agricultural land requirements grew so quickly that USDA conducted a study identifying "potential cropland"—land not used for crops that could be economically brought into crop production, including about 31 million acres of private forestland thought to have a high or medium potential for crop use. A similar assessment of marginal or highly erosive cropland that could be more suitably used for timber growing than crop production has not been undertaken on a comprehensive basis, but it could help determine long-term priorities for agriculture conservation programs if current grain surpluses and cropland set-aside programs continue. In addition, some marginal agricultural land reverts naturally to forestland each year but is usually poorly stocked with commercial species for quite some time. Because tree planting on agricultural land usually is cheaper than on harvested sites, determining the extent of such acreage and its management opportunities would be useful.

Management needs are difficult to establish without clarifying the role that wood can, could, or should play in the domestic and international economy. Economic models, such as those the Forest Service uses to project future supply and demand for wood, may be more useful for identifying alternative strategies for achieving goals once goals are set, than for establishing the goals themselves. The Forest Service demand projections, for example, have been criticized for overstating likely future demand for wood and for understating likely supply—and therefore may not provide a sufficiently accurate basis for formulating policies for timber management programs and for budgeting public or private expenditures.

Congressional Options

If more refined information about timber management needs is considered an important objective, Congress could:

1. Direct the Forest Service to supplement its previous assessment of "economic opportunities" for timber management with a separately conducted analysis of hardwood management opportunities to gain incremental improvement in timber quantity and quality without the need for expensive stand conversion and planting of softwood species.
2. Direct USDA to undertake a "potential forestland" management study to determine the extent of marginal or erosive agricultural land that may be better suited for timber production than crop or other agriculture uses.

Policy Issue F
Establishing Public and Private Management Priorities

Timber growth and harvest can be increased on all forest land ownerships. However, the potential for increased output and the means for stimulating production differ among the three major ownership groups.

Findings

- Government incentives for increased timber production on PNIF lands are modest and their results are complicated by diverse landowner attitudes, financial capabilities, and objectives. Greater emphasis on small-scale forestry research, technical assistance, education, and information programs probably would provide a broader stimulus to productivity than increased financial assistance, given the limited Federal funds available.
- The private sector will play the key role in funding timber management on its land, although government incentives may continue to supplement private efforts. The forest products industry contributes significantly to encouraging PNIF management through technical assistance programs and leasing arrangements; industry efforts of this sort could accelerate if Federal funding remains low. Several financial institutions now offer timberland investment programs that may channel additional capital into forest management.
- To help ensure adequate future wood supplies, the forest products industry could intensify management on its own lands, which generally are located near mills and are highly productive. Existing tax laws allowing capital gains treatment of timber income seem to have encouraged the industry to undertake more intensive management of its lands, although a conclusive cause-effect relationship between this tax incentive and management intensity has not been estab-

lished. Many nonwood-based corporations have substantial forest holdings that also afford added management opportunities.

- Timber production on Federal lands could be increased in the long run through more intensive management of lands allocated to this purpose. The RPA program endorsed by Congress proposed upgraded management on productive national forest land by 2030, but its implementaion will depend on whether adequate Federal funds are appropriated.

Current Policy Status

U.S. timber inventories have been increasing for several decades and will probably continue to do so under current levels of management. Supplies could be increased more rapidly, however, through greater implementation of existing intensive management technologies. Opportunities for achieving more intensive management vary among the three major ownership groups—private nonindustrial, forest products industry, and Federal—because of differing ownership objectives, financial resources, and land characteristics such as potential productivity, tract size, and location.

PNIF lands comprise 58 percent of the commercial timberland in the United States and contribute nearly half of the raw material used by the forest products industry. In the East, where 90 percent of the PNIF lands are located, they contribute an even larger portion of timber supplies.

Prospects are good for increased production from PNIF lands. Growth on these lands is increasing more rapidly than on other ownerships, and PNIFs generally can be expected to enlarge their contribution to timber supplies under current levels of management. Substantially greater timber supplies from PNIFs could be achieved in the long term through more intensive management. "Economic opportunities for management intensification" have been identified on 79 million to 124 million acres of PNIF lands, but these opportunities would be expensive ($6 billion to $9 billion) to implement. In addition, impediments such as market uncertainties, diverse landowner objectives, lack of awareness about investment opportunities, and small tract size may inhibit management investment.

Federal assistance to PNIF landowners includes research, education, technical assistance, and direct financial assistance through tax incentives and cost-sharing programs. Several USDA agencies in addition to the Forest Service provide service—i.e., the Agricultural Stabilization and Conservation Service, the Soil Conservation Service, the Cooperative Extension Service, and the Farmers Home Administration. Some programs channel aid to private owners through State forestry agencies. An interagency agreement on forestry defines individual agency responsibilities and coordination of forestry-related assistance.

The three 1978 laws that placed increased emphasis on State and private forestry were the Cooperative Forestry Assistance Act, the Forest and Rangeland Renewable Resources Research Act, and the Renewable Resources Extension Act. Still, the executive branch has given State and private forestry a low priority, proposing a 60-percent budget reduction for fiscal year 1984 in Forest Service support for State and private activities.

Several Federal tax provisions and cost-sharing programs provide timber-related benefits to PNIF owners. Capital gains treatment of timber income is by far the biggest of these (entailing a subsidy of about $180 million to individuals in fiscal year 1983) but does not require tax savings to be reinvested in management. Other tax incentives, such as tax credits for reforestation costs, explicitly require management, but on a limited basis and at far less Federal cost ($10 million to individuals in fiscal year 1983).

Direct cost-sharing is provided by the Forestry Incentives Program (cut from the proposed fiscal year 1984 budget) and the Agricultural Conservation Program, administered by the Agricultural Stabilization and Conservation Service in conjunction with the Forest Service. A criticism of these cost-sharing programs is that they may be used by people who would undertake timber management activities whether or not Federal funds were available.

Historically, the cost-sharing program that had the greatest impact on private nonindustrial tree planting was not a forestry program, but USDA agricultural program called the soil bank. Established by Congress in 1954, the now defunct soil bank paid farmers to keep some of their land out of production for at least 10 years and also provided cost-sharing assistance for tree planting. Although not a forestry program per se in that its key purpose was to reduce erosion and grain surpluses, PNIF land planted in trees during the high point of the soil bank era (1958-62) has never been surpassed. Soil bank plantations currently are reaching maturity in the South and are important to the region's timber supplies.

The present agricultural situation may be optimal for retiring some land from crop production for a protracted period. Grain surpluses are enormous, and erosion levels on some land are very high, especially on vulnerable cropland brought into production during the high demand years of the 1970's. In March 1983, USDA announced that farmers had enrolled 82 million acres of cropland for conservation use in its Payment-in-Kind (PIK) Program. The program is temporary, but longer term conservation programs are under consideration. Thus, there may be opportunities to meet national objectives related to farm income, soil conservation, and forestry through an extended program to encourage farmers to plant trees on highly erosive cropland better suited for timber production. Planting costs on idled cropland are less than on harvested areas where stand preparation must be conducted, but annual payments to farmers under the soil bank program were high. From a timber management perspective, a soil bank approach would not be cost efficient, but the cost may be more acceptable if other public objectives are taken into consideration. Alternative systems for cost-effective agricultural land retirement now under consideration do not necessarily entail annual payments to farmers.

The private sector may provide more assistance to PNIF owners in the future if Federal budgets stay low. Many forest products firms conduct programs to expand wood supplies in their procurement areas by providing advisory, financial, and operational services to local nonindustrial landowners. Some firms lease PNIF lands under long-term contracts that provide owners with regular income while their lands are managed for timber production.

More recently, financial institutions have begun marketing limited partnerships that could raise investment capital for timber management on private lands while providing tax shelters and future income to the investors. The effect of these limited partnerships on private forestland productivity is not yet known.

The forest products industry owns 14 percent of the Nation's commercial forestland and 44 percent of the highly productive commercial land—more than any other ownership group. Industry lands provide about one-third of the Nation's commercial harvest. Industrial lands have important potential for increasing U.S. timber production because they have high natural productivity, lie in large contiguous parcels, and tend to be located near mills. Furthermore, the large forest products firms that own the most industry land generally have access to investment capital, and timber production is the major landownership objective of these firms. Evidence suggests that industry lands are being managed more and more intensively, but a significant portion are still nominally managed or unmanaged altogether.

Capital gains treatment of timber income, which cost the Department of the Treasury $225 million in foregone corporate taxes in fiscal year 1983, may have encouraged industry investments in timber management. However, a direct cause-effect relationship is not clear since beneficiaries of the provision are not required to reinvest their tax savings in management. Other factors may have also contributed to the increase.

Federally owned lands comprise 18 percent of the Nation's total commercial forestland and provide about 15 percent of the timber harvested. Not all public lands classified as "commercial" are managed for timber production. Some have been allocated to other uses such as recreation or wildlife habitat. In addition, wilderness set-asides have removed 10.2 million acres of Federal commercial acreage from timber production, and management activities are restricted on additional acres that are being considered for wilderness. The law allows some flexibility for temporary increases in timber harvest on Federal commercial lands, but statutory changes would be needed to allocate more land to timber production under multiple use planning processes.

The Forest Service maintains that all economic opportunities for management intensification on national forest land are currently scheduled or planned. Although details have not been provided, such management would increase timber production on Federal lands in the future, but would require a significant increase in funding for planting and timber stand improvement.

Congressional Options

Numerous options are available to Congress should it determine that Federal incentives for timber management need to focus on the most cost-effective lands. Congress could:

1. Direct the Department of the Treasury, in cooperation with USDA, to report on the impact and effectiveness of current tax treatments and tax incentives in encouraging timber management and on alternative tax approaches for congressional consideration. Alternative approaches could include expanded "intensive management" investment tax credits to replace or supplement current capital gains treatment of timber income or tax incentives to encourage expansion of private sector landowner assistance programs.
2. Increase Federal PNIF assistance programs for research, education, extension, and technical assistance programs that are general in application.
3. Focus Government programs for direct Federal cost-sharing to landowners where important conservation objectives would be served by tree planting, such as on erosive or marginal cropland ill-suited for crop production, while relinquishing most cost-sharing assistance on other lands to the forest industry and financial institutions that are better able to determine cost effectiveness.
4. If general cost-sharing programs are maintained, direct USDA to establish priorities for Federal cost-sharing assistance to PNIF landowners based on factors such as tract size, potential productivity, and proximity to timber markets.
5. Direct the administration to intensify timber management on Federal lands allocated to timber production. Appropriate the funds required to implement intensified management programs.
6. Initiate hearings and other deliberations to investigate alternative timber management and timber sales procedures for Federal lands, such as a greater industry role in timber management activities in return for harvesting privileges.

CHAPTER III

World Markets for U.S. Wood Products

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CHAPTER III

World Markets for U.S. Wood Products

Summary

The United States is a major importer and exporter of wood products. **Since 1950, U.S. exports of forest products, in constant (deflated) dollars, have risen 400 percent, while imports have increased by roughly 75 percent.** Although the United States is still a net importer of forest products, the balance-of-payments deficit has narrowed, particularly since 1978. This is due primarily to increased exports of pulp and paper products and decreased imports of lumber caused by a precipitous decline in the housing market.

Growth in world demand for forest products may result in a 50-percent increase in consumption by 2000. In the next several decades, therefore, the United States has many unique opportunities to increase its exports, particularly in paper products. It has both the manufacturing capacity and the forest resource needed to expand production, and, unlike that of many traditional wood-producing nations, its inventory is increasing and accessible. This gives the U.S. forest products industry a sustainable advantage in world markets. Many of the world's forests, especially in Latin America and the eastern Soviet Union, are remote and inaccessible, and the investment needed to bring these forests into commercial production may be prohibitive. Southeast Asia, another major wood-producing area, has been heavily deforested, and harvesting rates that prevailed in the 1970's probably are not sustainable.

Most of the world's increased forest products consumption probably will come from industrialized nations. Major foreign markets for U.S. forest products in the future are Western Europe and Japan, which will probably rely more heavily on U.S. woodpulp and paper. Promotion of U.S. homebuilding techniques may be instrumental in expanding markets for lumber and panel products as well. U.S. producers will have little trouble increasing exports of raw materials such as logs, wood chips, waste paper, and woodpulp. The United States also is in a favorable position to expand its exports of linerboard.

A wide variety of trade barriers, however, will limit the ability of the United States to expand its exports of processed products such as lumber, panels, and paper. Efforts to ease or eliminate some of these barriers are underway, although there is little likelihood that the United States will gain free access to Western European and Japanese markets. In addition, U.S. exporters are at a disadvantage on world markets due to the overvaluation (strength) of the dollar against foreign currencies and worldwide recession. Improvements in these financial conditions probably will stimulate exports of wood products even without substantial progress in reducing trade barriers. The formation of export trading companies, now permitted under U.S. law, also may improve the competitive position of U.S. exporters.

The United States probably will continue to import substantial quantities of lumber, woodpulp, and newsprint from Canada. Canada's proximity to major consuming regions of the United States, the availability of low-cost transportation, and the distribution of the Canadian softwood resource combine to make Canadian products competitive in U.S. markets.

World Markets for U.S. Forest Products

The United States has an unprecedented opportunity to expand its exports of many forest products. There are three principal reasons for this: 1) world demand for paper and solid wood products are expected to grow rapidly, 2) many established wood-producing nations are confronted with diminishing wood supplies, and 3) the United States has both an abundant wood resource and a highly developed manufacturing capacity compared with most other countries.

The United Nations Food and Agriculture Organization (FAO) projects that world demand for industrial roundwood will grow by about 2 percent per year for the next 20 years.[1] According to FAO, consumption of paper and paperboard is expected to increase by 75 percent, wood-based panels by 55 percent, and lumber by 25 percent between 1980 and 2000.[2] Although these projections are not necessarily accurate, they do point out prospects for growth in world forest products consumption. Much of this increase is expected to occur in the developed countries of Western Europe, North America, and Japan, although demand for paper and solid wood products in developing nations is expected to increase as well.

Regional trends in industrial roundwood production suggest that traditional suppliers cannot continue to increase production at past rates, and some probably will not even be able to maintain present rates. Wood supplies from the western Soviet Union, which are important to Eastern and Western Europe, declined during the 1970's and probably will continue to decline. While the U.S.S.R. has vast softwood forests in Siberia, much of this area is inaccessible and manufacturing capacity is lacking. Western Europe, which has depended on the Soviet Union for some of its wood, can expand its timber harvests somewhat, but probably not enough to compensate for declining Soviet supplies coupled with rising demand. Timber resources in the Far East, which supply the majority of Japanese wood imports, are shrinking. Recent hardwood production levels in Far Eastern countries outside Japan probably cannot be sustained through 2000, and some of these nations are beginning to restrict log exports.

Many Far Eastern countries, especially Japan, will become more dependent on imports from other regions to satisfy growing demand for forest products. Although Latin America has vast acreages of forests, it will probably not become a major competitor with U.S. forest products on world markets before the turn of the century. The situation in South America is similar to the Soviet Union's—forests are remote and inaccessible, and the capacity to process more than a fraction of the potential harvest does not exist. Some past efforts to establish forest products manufacturing industries in Brazil have failed, and the enormous capital requirements to build South America as a major world supplier of forest products (other than pulp) by 2000 are almost certainly beyond the means of these developing nations.

In contrast, the forest resource of the United States is increasing. Between 1952 and 1977, growing stock on its commercial forestland increased nearly 20 percent.[3] Harvest levels have been remarkably stable, from 10 billion to 14 billion cubic feet (ft^3) per year since the early 1900's. U.S. forests can support substantially larger harvests, even with increasing domestic demand.

U.S. trade in forest products has different effects in different areas of the country, depending on the availability of supplies from foreign and domestic forests and on manufacturing capacity (tables 5 and 6). In 1976, the Great Lakes

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[1] Cited in Environment Canada, *Policy Statement: A Framework for Forest Renewal,* Ottawa, Canada: Sept. 2, 1982, p. 2.

[2] Cited in "A Forest Sector Strategy for Canada," discussion paper Sept. 30, 1981, p. 7.

[3] U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the Undited States, 1952-2030,* Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, December 1982), p. 113.

Table 5.—Pulp and Paper[a] Trade Patterns, by U.S. Region, 1976

Region	Imports (millions of dollars)	Major supplier	Exports (millions of dollars)	Major customer	Trade balance (millions of dollars)
Pacific Northwest	141	Canada	309	Japan	168
South Atlantic	15	Western Europe	449	Western Europe	434
Gulf	26	Western Europe	485	Western Europe	459
North Atlantic	341	Canada	354	Western Europe	13
South Pacific	23	Japan	117	Asia	94
Great Lakes	755	Canada	238	Canada	-517
North Central	158	Canada	19	Canada	-139
South Central	—	—	9	Mexico	9
Alaska	—	—	67	Japan	67

[a]Excluding waste paper.

SOURCE: Sedjo and Radcliffe, *Postwar Trends in U.S. Forest Products Trade* (Washington, D.C.: Resources for the Future, 1980).

Table 6.—Solid Wood Trade Patterns, by U.S. Region, 1976

Region	Imports (millions of dollars)	Major supplier	Exports (millions of dollars)	Major customer	Trade balance (millions of dollars)
Pacific Northwest	422	Canada	1,246	Japan	824
South Atlantic	103	Far East	40	Europe	-63
Gulf	130	Far East	54	Europe	-76
North Atlantic	342	Canada	126	Europe	-216
South Pacific	82	Far East	90	Japan	8
Great Lakes	627	Canada	173	Canada	-454
North Central	230	Canada	36	Canada	-194
South Central	1	Mexico	6	Mexico	5
Alaska	1	Canada	77	Japan	76

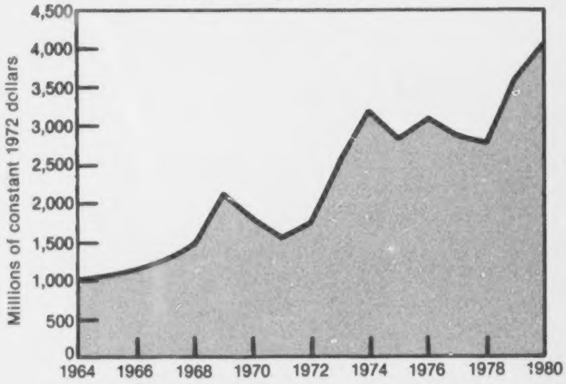
[a]Excluding waste paper.

SOURCE: Sedjo and Radcliffe, *Postwar Trends in U.S. Forest Products Trade* (Washington, D.C.: Resources for the Future, 1980).

States and the North Central region were net importers of paper and pulp, most of which came from Canada, while other regions were net exporters. Conversely, the Pacific Northwest, Alaska, and the South Central region were net exporters of solid wood products, although the trade surplus in the Pacific Northwest is much larger than the deficit in any other single region. Efforts to increase exports are likely to benefit the Pacific Northwest, Alaska, and the Southern regions (South Atlantic, Gulf, and South Central States). The Great Lakes States and the North Central region, which are close to cheap water transportation and Canadian softwood forests, probably will remain net importers of most forest products.

For at least the past two decades, U.S. exports of forest products have increased (fig. 2), but in general, the United States still is a net importer. This may be changing. Since 1978,

Figure 2.—Value of U.S. Exports of Wood Products,[a] 1964-80



[a]Wood products here include waste paper and paperboard, and do not include converted products (numbers for waste paper exports obtained by phone conversation with API representative).

SOURCES: United Nations Food and Agriculture Organization, *1980 Yearbook of Forest Products* and *1975 Yearbook of Forest Products*. American Paper Institute, personal communication.

the U.S. deficit in forest products trade has narrowed sharply, primarily due to an increase in exports of pulp and paper products (fig. 3).

In 1982, the United States exported forest products (paper, paperboard, logs, lumber, railroad ties, wood-based panels, woodpulp, and wood chips) valued at $7.3 billion. The largest markets for these products were Western Europe, Canada, and Japan, markets that can expand considerably. There are also opportunities to develop totally new markets.

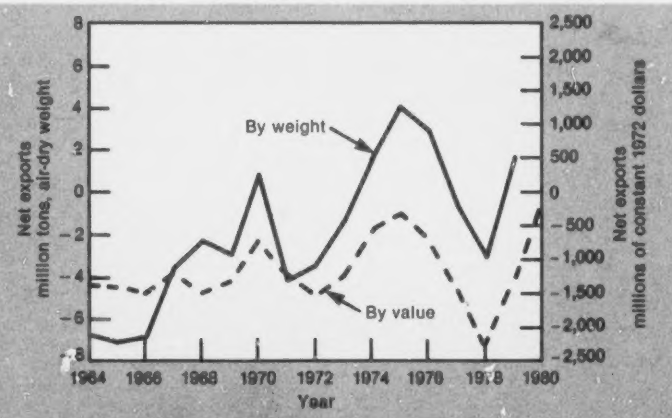
While world markets offer the United States an opportunity to sustain a positive balance of trade in forest products, it is unlikely that the United States will reduce or curtail its imports. The United States is a major importer of softwood lumber, newsprint, and woodpulp, most of which comes from Canada. Reliance on inexpensive Canadian products, in fact, enables the United States to develop greater export capacity in other product lines, such as linerboard, clear lumber, panels, printing and writing papers, and converted paper products, many of which have higher value added than imports.

Established Markets for Pulp and Paper Products

In 1979, international exports of forest products amounted to about $46 billion, nearly 3 percent of total world trade. Roughly one-third of this involved paper and paperboard. In 1982, U.S. exports of pulp and paper totaled $4.3 billion. In deflated dollars, this was slightly lower than 1980 levels, reflecting worldwide recession, the strength of the dollar against foreign currencies, and, in some cases, protectionist pressures.[4] Between 1972 and 1981, however, the tonnage of U.S. exports of woodpulp has increased 63 percent and paper, paperboard, and converted products by 50 percent. Waste paper exports increased 450 percent between 1971 and 1981.

U.S. pulp and paper producers are in a better position to expand exports than are producers of lumber, panels, and other solid wood products for several reasons. Demand for pulp

Figure 3.—U.S. Balance of Trade in Wood Products,[a] 1964-80



[a] Wood products here include waste paper and paperboard and do not include converted products. With the exception of waste paper and paperboard, only wood fiber component of products is included in total tonnage. In the case of waste paper and paperboard, other constituents such as clay fillers are included.

SOURCES: U.S. Department of Agriculture, Forest Service, *U.S. Timber Production, Trade, Consumption, and Price Statistics, 1950-1980*, p. 10; and United Nations, Food and Agriculture Organization, *Yearbook of Forest Products, 1980*, pp. 359, 361 and *Yearbook of Forest Products, 1975*, pp. 301, 303. American Paper Institute.

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[4] American Paper Institute, International Department, "Exports of Pulp, Paper, Paperboard, and Converted Products to World Markets—1981" (New York: American Paper Institute, 1981).

and paper is intrinsically less cyclic than demand for solid wood products. Moreover, the pulp and paper sector of the forest products industry is highly capital intensive, production is large-scale, and the sector must operate very close to capacity to maintain profit margins. This situation provides strong incentives to maintain lasting agreements with all customers, domestic or foreign. In addition, market pulp and many types of paper are commodity (or standard) products in world markets, while lumber and panel products tend to be specialties overseas. Producers of lumber and panels often must devote substantial effort to create foreign demand through the promotion of U.S. building techniques and product specifications and performance. In contrast, demand for most U.S. paper products already exists. Finally, due to a combination of labor and resource availability, energy costs, and production efficiency, U.S. pulp and paper are fully cost competitive in world markets.[5]

Western Europe

Western Europe is the largest single market for U.S. pulp and paper products. It accounted for 49 percent of U.S. exports of woodpulp and 21 percent of U.S. exports of paper, paperboard, and converted products. Over the past decade, however, Western Europe's imports of U.S. paper, paperboard, and converted products have declined in both percentage and tonnage, while woodpulp imports have increased (figs. 4 and 5). This shift is probably a result

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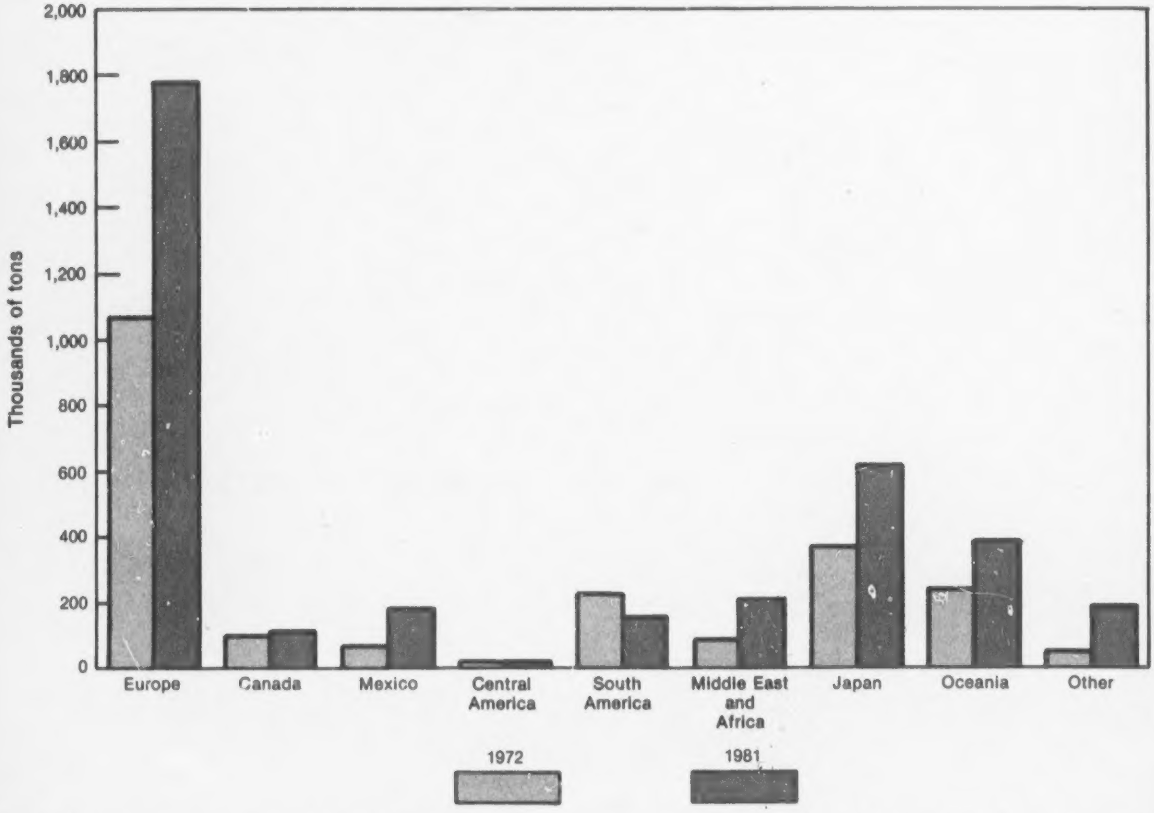
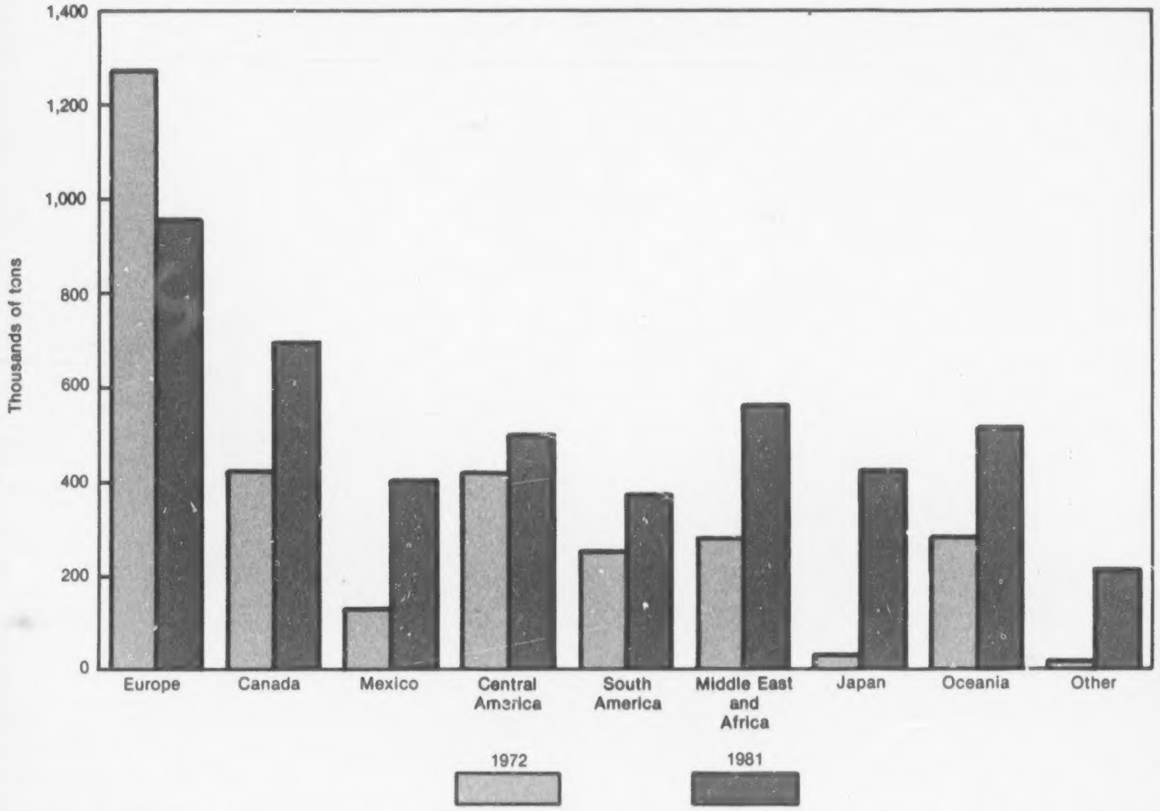
[5] American Paper Institute, "The American Paper Industry: An International Profile," paper submitted to the Industry Sector Advisory Committee No. 12, Aug. 12, 1982, p. 6.

Figure 4.—Woodpulp Exports by Area of Destination



SOURCE: American Paper Institute, "Exports of: Pulp, Paper, Paperboard, and Converted Products to World Markets—1981," New York: API International Department, n.d., p. xxiv.

Figure 5.—U.S. Paper, Paperboard, and Converted Products Exports, by Area of Destination



SOURCE: American Paper Institute, "Exports of: Pulp, Paper, Paperboard, and Converted Products to World Markets—1981," New York: API International Department, n.d., p. xxv.

of decreased exports of woodpulp from Scandinavia to other Western European countries. Scandinavian woodpulp prices have been rising because major producers are paying much higher prices for pulpwood than their North American counterparts (fig. 6). As a result, Scandinavian producers are facing losses of Western European pulp markets. In addition, Scandinavian production costs are considerably higher than those of North American competitors, and many marginal Scandinavian mills are closing.[6] Scandinavian producers are increasing their papermaking capacity in integrated mills which are efficient enough to produce paper at prices competitive in the European Community, displacing imported paper from other sources. The trend toward integration has focused on high value products, which will probably force higher reliance on North American kraft linerboard as well as pulp. In the short run, Scandinavian paper probably will continue to satisfy a large part of Western Europe's paper demand, but the capacity to increase production is limited. In the long run, particularly with an economic recovery, Western Europe is expected to increase its reliance on North America for paper products.[7] [8] [9] [10]

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[6] J.W. Garrigan, "International Outlook for Pulp, Paper and Paperboard Products," *Paper Trade Journal*, 165(6): p. 22, Mar. 30, 1981.

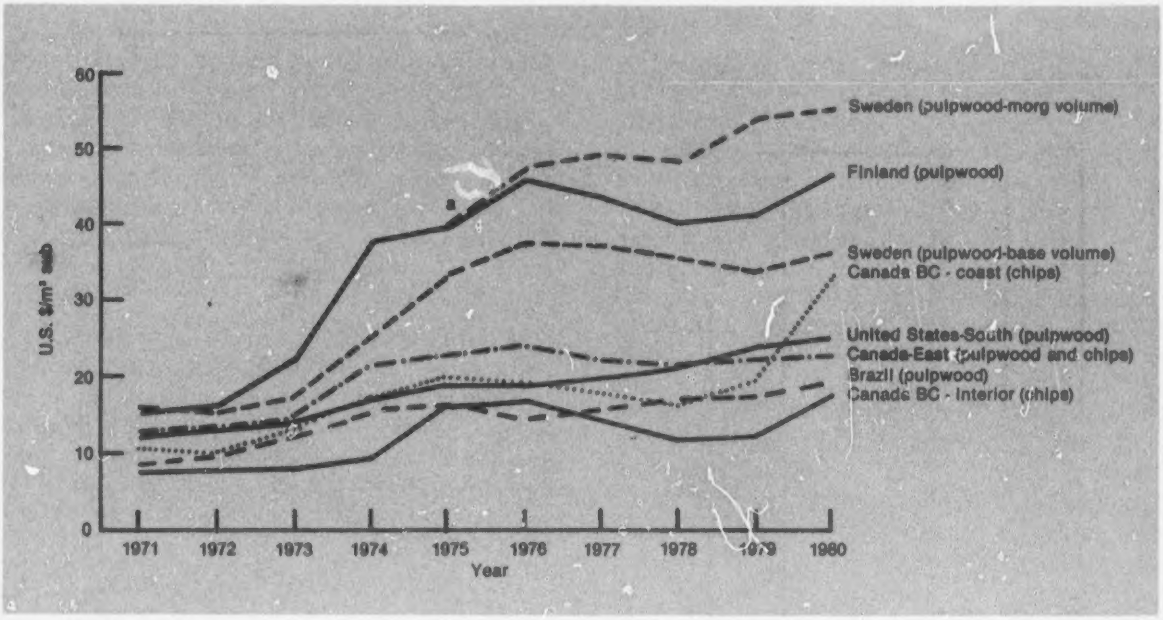
[7] "The Battle is on for Control of Europe's Paper Market," *World Business Weekly*, June 15, 1981, pp. 22-23.

[8] "North America Newsprint Exports: Today and Tomorrow," *Paper*, May 10, 1982, p. 48.

[9] Kenneth E. Smith, "SPCI Focuses on World Fiber Deficit, Competition From North America," *Pulp and Paper*, August 1981, pp. 179-185.

[10] "World Review," *Pulp and Paper*, August 1981, p. 66.

Figure 6.—Pulpwood Cost (Softwood) at Mill Site by Volume, Under Bark Basis, Current General Overhead, Estimated at 5 Percent, Included



[a] Not available before 1975.

SOURCE: Jaako Poyry Interforest. Prospectus for the 1982 edition of *Availability and Cost of Wood in Major Forest Product Regions 1970-1990*, 1983, Finland, p. 11.

While the tonnage of all paper, paperboard, and converted products exported to Western Europe has fallen in the last decade, the mix of products has changed significantly. Western Europe now is importing larger amounts of printing and writing papers and bleached paperboard than in 1972, while imports of unbleached kraft linerboard (primarily used in making corrugated boxes) have fallen. In the future, Western Europe is expected to increase its imports of paper in which woodpulp accounts for relatively large shares of the product value, such as in newsprint and linerboard.

Canada

In 1981, Canada imported 15 percent, or almost 700,000 short tons, of the U.S. paper, paperboard, and converted products and a smaller percentage of its woodpulp. Exports of paper products to Canada have increased 65 percent since 1972 and are expected to continue to rise. Over half of these exports are printing, writing, and converted products (paper which has been converted to product form, such as envelopes, corrugated and other boxes, tissues, and paperboard cartons and drums).

Although Canada is a major paper producer itself, well equipped to compete in world markets for paper products based on softwoods, it lacks a hardwood resource. As a result, Canada is expected to rely on its North American neighbor for paper products that require significant amounts of hardwood pulp. In addition, Canadian pulp, newsprint, and other writing papers are cost competitive with U.S. products.

Japan and the Far East

In the past decade, U.S. exports of paper, paperboard, and converted products to Japan and the Far East have tripled (fig. 3). Most of this large increase was due to an expansion of Japanese imports of unbleached kraft linerboard, bleached paperboard (for which Japan has almost no domestic production capacity), and newsprint (largely due to U.S.-Japan joint ventures).

Japan is a major paper producer. It ranks second in paper and paperboard and third in pulp worldwide. However, it is facing increasing costs for raw materials, energy, and pollution controls that threaten to place many grades of Japanese paper among the world's most expensive.[11] [12] Exports of paper, paperboard, and converted products to Japan alone have increased almost 14 times in the last decade, accounting for most of the expansion into Far Eastern markets for U.S. paper. This increase reflects Japanese difficulties in obtaining inexpensive raw materials for their pulp and paper mills and an unfavorable climate for investment in milling capacity.[13] As a result, the Japanese have relied more heavily on imported pulp and paper to satisfy growing demand for paper and paperboard products.[14] [15]

About half of the raw material used in Japanese pulpmills is hardwood pulpwood and log processing residues, with most hardwood logs imported from other Far Eastern countries. The levels of hardwood harvesting prevalent in the 1970's in these countries probably are not sustainable through the end of this century. This looming problem, combined with a growing tendency for some Far Eastern nations to shift exports from logs to processed products, means that the Japanese probably will rely more heavily on North America for wood chips, woodpulp, and paper in the future.[16] Competition among the United States, Canada, Oceania, Southeast Asia, and Chile for Japanese pulp and paper markets, however, may be quite intense.[17] [18]

Countries in the Far East and Oceania, other than Japan, imported 11 percent of U.S. paper, paperboard, and converted products exports in 1981, up from 9 percent in 1972. In tonnage, exports to these countries increased by 80 percent in the last decade. Woodpulp exports to Far Eastern countries other than Japan have remained stable in terms of percentage, accounting for just over 10 percent of U.S. woodpulp exports during the last decade (fig. 5).

China may become a major market for U.S. paper products within the next decade, too, particularly in packaging material. In 1980, much of China's linerboard came from Japan, but lower cost U.S. linerboard may become more competitive in the Chinese market.[19]

Other Markets

The United States sold nearly 16 percent of its woodpulp and 40 percent of its paper, paperboard, and converted products to Mexico, Central America and the Caribbean, South America, the Middle East, and Africa in 1981 (figs. 4 and 5). These percentages have remained fairly stable over the last decade, although woodpulp exports fell slightly, primarily due to fewer sales to South America.

Mexico's value share of U.S. paper, paperboard, and converted products exports doubled and the tonnage tripled (fig. 4). These large increases occurred despite stricter licensing requirements and import duties that cut Mexico's imports of U.S. packaging and industrial converting grades of paper. Nevertheless, Mexico remains the biggest single purchaser of U.S. printing, writing, and tissue paper, while importing large amounts of other kinds of paper and paperboard as well.

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[11] "The American Paper Industry: An International Profile," op. cit., p. 14.

[12] "World Review," p. 66.

[13] U.S. Department of Agriculture, Forest Service, Alaska Region, *Timber Supply and Demand 1981*, mimeograph draft report to Congress in compliance with the Alaska National Interest Lands Conservation Act, Apr. 1, 1982, p. 39-40.

[14] Y. Shiota, and A. P. Schniewind, "Recent Trends in the Wood Industry of Japan," *Forest Products Journal*, June 1980, p. 23.

[15] Garrigan, "International Outlook," op. cit., p. 23.

[16] *Timber Supply and Demand*, op. cit., p. 42.

[17] Ibid., pp. 45-46.

[18] David R. Darr, "The Impacts of International Trade on Domestic Markets," Proceedings, *The Impact of Change on the Management of Private Forest Lands in the Northwest*, Portland, Oreg., Mar. 29-31, 1978, pp. 30-31.

[19] *Timber Supply and Demand*, op. cit., p. 45.

South America, with over 13 billion acres of exploitable forest, became a net exporter of woodpulp during the past decade. On the other hand, its imports of U.S. paper, paperboard, and converted products increased by nearly 50 percent. The immense forest resource of South America could become a major world source of wood, but this is not likely to happen in the near future. The continent does not have the transportation and manufacturing capacity to support increased production of processed wood products, and the amount of capital required to develop this capacity is probably beyond the immediate means of these nations. Technologies for using South American mixed hardwoods exist, but substantial investments must be made before these forests can be fully exploited. South American markets for U.S. paper and paperboard may continue to be fairly strong for the next few decades.

The United States also should have a strong competitive position in supplying paper to the Caribbean, Africa, and the Middle East in the future. Caribbean markets have the advantage of proximity to the highly productive forests of the American South, which means ample supplies and lower transportation costs. Exports of both woodpulp and paper products to this region probably will expand. Africa and the Middle East have little forest area and lack the capacity to exploit what few trees do exist. Africa and the Middle East accounted for 12 percent of U.S. paper and paperboard exports in 1981, up from 9 percent in 1972. Continued economic growth in this region probably will mean expanding markets for all products.

Established Markets for Solid Wood Products and Raw Materials

In 1982, the U.S. exported solid wood products* valued at $2.6 billion—down from $3.2 billion in 1979—reflecting the effects of worldwide economic recession.[20] Over 40 percent of the 1981 value was in logs and timber, of which 75 percent was softwood logs exported to Japan. Lumber and railroad ties accounted for 34 percent of solid wood product exports, and the remainder was divided among pulpwood, wood chips, wood wastes and fuels, and wood-based panels (table 7). The major market areas are Western Europe, Canada, and Japan.

Table 7.—U.S. Exports of Solid Wood Products, 1981

Product	Quantity (thousands)	Value (thousands of dollars)	Percent of value
Logs and timber (board ft)	2,534,224	$1,094,716	40.76%
Hardwood	157,125	91,868	3.42
Softwood	2,377,099	1,002,848	37.34
Pulpwood (cords)	176	9,911	0.37
Wood chips (short tons)	3,546	290,184	10.80
Wood waste, wood fuel	NA	12,894	0.48
Lumber and railroad ties (board ft)	2,374,055	923,784	34.40
Hardwood lumber	381,481	243,026	9.05
Softwood lumber	1,903,809	655,544	24.41
Railroad ties	88,765	25,214	0.94
Wood-based panels	NA	354,293	13.19
Softwood plywood and veneer	NA	189,727	7.06
Other	NA	164,566	6.13
Total	—	2,685,782	100.0

SOURCE: U.S. International Trade Commission.

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*Logs, timber, pulpwood, wood chips, waste and fuels, lumber and railroad ties, and wood-based panels.

[20] The figure for 1979 differs from the $3.8 billion that the National Forest Products Association cites in *Increased Wood Products Exports: A Bonus for the Industry and Nation*, International Trade Committee (Washington, D.C.: National Forest Products Association). OTA figures are based on unpublished data from the U.S. Department of Commerce, International Trade Commission. NFPA also cites Department of Commerce data, but it is not disaggregated to permit detailed comparison.

The United States exports substantially larger quantities of raw materials (e.g., logs and chips) than most other exporters of solid wood products. There is some pressure, particularly on the American west coast, to limit log exports in favor of lumber and panels. However, while log exports may create fewer jobs per unit of volume in the United States than exports of processed products, the average dollar value of softwood logs exported to Japan is higher than the average value of exported softwood lumber.* Log exports, therefore, are more valuable in creating foreign exchange and help to maximize the value the United States realizes on its raw materials.

Western Europe

Twelve percent of U.S. softwood lumber exports in 1981 went to Western Europe. Although this portion is substantially smaller than in the preceding decade, for the past 30 years softwood lumber exports to this area have been increasing slowly, though erratically. Western Europe historically has imported clear Douglas-fir and southern pine lumber, but the increasing popularity of platform frame (2 x 4) construction in some countries may open markets to a wider range of sizes and grades of these softwood materials.

The most important market for U.S. hardwood lumber is Western Europe, which is a major customer for hardwood logs and veneer. U.S. exports of these products to the European Community and Spain have tripled since 1977. Given Western European tastes for fine furniture, markets for hardwood lumber and logs, particularly high-quality logs suitable for veneer, may be larger in the future.[21] Presently, however, some countries are concerned about oak wilt, a U.S. oak fungus which reportedly does not exist there, which could be transmitted in imported goods.[22] Solving this problem could pave the way for more U.S. hardwood exports.

Western Europe is the biggest buyer of U.S. panel products, mostly softwood plywood. The trend toward platform frame construction already visible in the United Kingdom, is expected to create even larger markets for U.S. plywood.[23] The potential for this expansion is strong, particularly if efforts to reduce or eliminate Western European tariffs on plywood are successful.[24]

Canada

Between 1950 and 1981, Canada's imports of lumber from the U.S. increased over sevenfold, with most of the growth in softwood lumber. Much of the lumber exported to Canada consists of species, grades, or sizes not available there—redwood, for example. In 1979, Canada accounted for 30 percent of U.S. lumber exports. Log exports to Canada, which have increased almost tenfold since 1950, account for about 10 percent of the logs that the United States sells abroad.[25]

With Canada so near, some U.S. producers can supply products to local Canadian markets, which in some cases may be cheaper than Canada's own goods. This situation probably will not change, but the United States undoubtedly will continue to import more solid wood products from Canada than it exports there in the foreseeable future. The United States probably will remain reliant on cheaper Canadian lumber for quite some time.

Japan

Japan is by far the biggest Far Eastern buyer for U.S. solid wood products. Most of these imports are softwood logs, for which the United States is the largest supplier and the Soviet Union is the second largest.[26] The United States also exports substantial quantities of wood chips, woodpulp, and softwood lumber to Japan, along with a variety of other products, including hardwood logs and lumber, wood panels, waste paper, and pulpwood. Between 1979 and 1981, U.S. log exports to Japan, which represent over half the value of all U.S. solid wood products sent there, decreased 13 percent, while exports of all other solid wood products increased. The outlook for continued log and wood chip exports to Japan is favorable, although other suppliers in New Zealand, Canada, the eastern Soviet Union, and Chile probably will compete.

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*There are several reasons why the Japanese pay higher prices for U.S. logs than for U.S. lumber. Some Japanese log imports are high value species. Also, the Japanese lumber manufacturing process produces higher value lumber than most U.S. manufacturers.

[21] Harold W. Wisdom, "The Export Market for Hardwoods," June 1978, p. 14-18, paper presented at the Society of American Foresters Annual Convention, Sept. 20-22, 1982, Cincinnati, Ohio, p. 14.

[23] National Forest Products Association and the U.S. Foreign Agricultural Service, *Forest Products Industry FAS/NFPA Foreign Market Development Plan FY 82* (Washington, D.C.: National Forest Products Association, International Trade Division, Sept. 1, 1981), p. 2.

[22] "British Columbia Fights Back," *Timber Trade Journal*, October 1982, pp. 19-21.

[24] National Forest Products Association and the U.S. Foreign Agricultural Service, *Foreign Market Development Plan*, pp. 1-40.

[25] *Analysis of the Timber Situation*, op. cit., pp. 317-331.

There is great potential to expand lumber exports to Japan to satisfy the nation's growing housing needs. North American standard sizes and grades of lumber, however, are not well suited to Japanese construction standards and methods, but while both the United States and Canada are aggressively promoting North American platform frame construction, only a small fraction of Japanese homes are built this way. Traditionally, the Japanese use wood as both decorative and structural components of their houses by leaving wood framing members exposed for esthetic appeal. U.S. construction grade lumber usually is not suitable for these purposes. There has been some progress in adapting Japanese inspections and standards to U.S. products, and some industry analysts see this as a promising development for increased exports of U.S. lumber to Japan.[27] Canada has been quite active in courting Japanese lumber markets, too, although a significant portion of the lumber Canada sends there consists of squared logs that are sawn to final dimensions at their destination. In the future, Canada probably will provide strong competition to U.S. producers. Furthermore, Canadian producers have been more willing than their U.S. counterparts to saw lumber to the metric sizes preferred in Japanese (and other world) markets.

The availability of logs to Japan is another factor that could limit progress in promoting exports of U.S. lumber. Japanese lumber is protected by tariffs, but logs are imported duty-free. Japan may continue to import mainly logs as long as it has access to them, even if it adopts Western construction methods using U.S. lumber grades.[28] [29]

There are also opportunities for increased softwood plywood exports to Japan. These opportunities, like opportunities to export softwood lumber, depend to some extent on Japanese acceptance of platform frame construction. The Japanese plywood industry, which produces mainly hardwood plywood, is the second largest in the world and is protected by a number of tariff and nontariff barriers discussed in more detail below.

Other Markets

Other encouraging markets for U.S. solid wood products exist elsewhere. Increased trade in these products shows promise in the Far East, particularly China. Exports of softwood logs to China have increased, which some analysts see as the first step to opening Chinese markets for other wood products.[30] Trade with mainland China is difficult, however, and conditions uncertain. Hong Kong, South Korea, Taiwan, and Singapore, all rapidly growing and industrializing, lack adequate forest resources. Australia and New Zealand are attractive markets for U.S. solid wood products because these countries have high purchasing power and similar business practices. Australia may offer particular near-term potential for U.S. exporters, but it has a policy encouraging self-sufficiency in forest products. New Zealand is and probably will continue to be a net exporter of wood products.

Many South American nations are heavily forested and probably will continue to protect their own forest industries. Many of the people of South America are extremely poor, and there is a limited clientele among those wealthy enough to afford foreign goods. Even as affluence increases, cultural preferences may not stimulate much demand for wood. In Chile, for example, a wooden house is seen as a sign of poverty.

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[26] *Increased Wood Products Exports*, op. cit., p. 27.

[27] Ibid., p. 28.

[28] John V. Ward, Director, International Trade, National Forest Products Association, letter to Louis Murphy, U.S. Department of Commerce, Office of International Sector Policy with attachments, Sept. 19, 1981.

[29] Darr, op. cit., pp. 29-30.

[30] Personal communication with John V. Ward, Director, International Trade, National Forest Products Association.

The most promising South American markets are probably Argentina and Venezuela. Argentina has a European-like culture with European housing tastes. Venezuela, strengthened by its petroleum exports, has a high standard of living and ambitious development plans. Its current housing shortage is tremendous. However, the recent drop in world oil prices have hurt Venezuela, and its potential as a major importer of U.S. solid wood products probably depends on recovery of oil markets.[31] The Caribbean and Mexico also may become more important customers for the United States.

Enriched by oil export revenues, Egypt, Saudi Arabia, and the other oil exporting countries of the Arabian peninsula, have set off a huge construction boom. There is potential for growth in this Middle East market in modular or prefabricated buildings and building components as well as lumber, plywood, panels, and other solid wood products.[32] These countries have almost no forest resources or industries of their own, but they do have liberal trade policies. Their populations are small, however, and it is possible that these markets can be saturated quickly. They, too, have been hurt by falling oil prices, which could limit their near-term potential as solid wood importers.

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[31] Hugh Love, "Latin America Emerges as Big Market for U.S. Wood Products," *Foreign Agriculture,* December 1982, p. 8.

[32] John R. Forrest, *World Trade Opportunities in Wood Products,* presented to Forest Industries Advisory Council, February 1982, p. 8.

Barriers to U.S. Trade in Wood Products

World trade in forest products is shaped not only by the general forces of supply and demand but also by tariffs and traditional quotas, nontariff barriers or distortions, and economic and governmental performance. Since World War II, the General Agreement on Tariffs and Trade (GATT) has been very effective in reducing its members' tariffs and traditional quotas,* and the subsequent growth of international commerce has been impressive. However, the use of nontariff barriers (NTBs) also has grown and often poses a more potent threat to free trade than tariffs and quotas. Governmental policies and worldwide economic conditions also exert a powerful influence, as the recent global recession illustrates.

Tariffs and Traditional Quotas

GATT, both a treaty and an organization, was established in the postwar years to provide a set of negotiated rules to govern world trade. The United States, the principal creator of GATT, always has seen it as a vehicle for reducing tariffs, quotas, and other trade barriers and GATT has been successful indeed in easing both tariffs and traditional quotas of member nations. Many tariffs and quotas remain, however, and these can be very influential in determining the character of trade in forest products.

In general, tariffs and traditional quotas restrict imports of processed products, such as lumber, plywood, paper, paperboard, and panels, more than raw materials. Even nations whose forest resources are small or nonexistent often restrict imports of processed products, preferring to import raw materials such as logs, pulpwood, wood chips, and woodpulp, to capture the value added employment in processing them.

While GATT has effectively reduced the general level of tariffs, it does permit preferential trade agreements. These can be particularly troublesome for forest products exporters in the United States. Preferential trade agreements include customs unions, common markets, and free trade associations, and provide for the reduction or elimination of tariffs or quotas from participating countries. Imports from nonparticipants are subject to quotas or regular most favored nation (MFN) rates, preventing nonmembers from competing fully in preferential areas. This is particularly important in Western Europe, where countries of the European Economic Community (EEC, or Common Market) and the European Free Trading Association (EFTA) are better able to compete in Western European markets for solid wood and paper products than the United States. Swedish papers, for example, are assessed lower tariffs in the European Community (EC) than U.S. or Canadian paper products, and as of 1984 will be assessed no tariff at all. While this places the United States at a comparative disadvantage, restructuring of Western European paper markets is expected to lead to expanded markets for North American kraft linerboard and kraft pulp.[33] Opportunities for increased U.S. exports of all types of paper and paperboard depend on implementation of recently negotiated tariff reductions and Western European ability and willingness to resist growing protectionist tendencies in its own paper industry. Pulp exports are not subjected to any significant tariff in the EC.

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*Traditional quotas are formal quotas which are public and usually codified into law.

Japan also maintains tariffs on paper and paperboard. Under the latest round of GATT negotiations in the 1970's (the so-called Tokyo Round of Multilateral Trade Negotiations), the Japanese agreed to lower some tariff rates by 1987. Under strong pressure from the United States, some of these tariff reductions were accelerated. In January 1983, the Japanese cut tariffs slightly on kraft paper and paperboard, while most other wood and paper tariffs went unchanged.

The Canadian situation on paper and paperboard products is still awaiting resolution. Under the so-called Kennedy Round of Multilateral Trade Negotiations in the late 1960's, Canada and the United States agreed to certain tariff reductions for paper products. As a result, the United States eliminated its duty on printing and writing paper and lowered tariffs on other products. Canada reduced its tariffs on printing and writing papers, but failed to bring tariffs on linerboard, bleached board, and recycled paperboard to the same level.[34] Furthermore, the two countries disagree on tariff reductions on other types of paper. These disagreements currently are being negotiated.

U.S. solid wood products also are affected by tariffs and quotas in the European Community. Technically, softwood plywood is duty-free but subject to a restrictive quota. Above the amount allowed by the quota, European Economic Community tariffs on softwood plywood are 11.6 percent. Recently, the French Government petitioned for a quota on imported softwood lumber, but this quota probably would be temporary if enacted.[35] The Tokyo Round was successful in easing some Western European barriers to solid wood products trade. By 1987, the EC's tariffs on wood products will be sharply reduced, with no tariff on logs or most types of rough lumber, a 4 percent tariff on finished lumber, and a 6 percent tariff on most veneer. Softwood plywood, however, still will be subject to a duty over quota.

Japanese tariffs on plywood and lumber are of more concern. While Japan welcomes imports of logs and some types of rough lumber duty-free, it collects tariffs on finished lumber, some veneers, plywood, millwork and molding, and particleboard ranging from 9 to 20 percent. Japan's system of small decentralized sawmills and finishing plants is one of its industries "targeted" for special protection, and progress in achieving tariff reductions probably will require some concessions from the United States. While many U.S. producers do not consider lumber tariffs a major problem, plywood duties are higher, and many producers prefer that they be cut.

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[33] "The American Paper Industry: An International Profile," op. cit., p. 12.

[34] Ibid., pp. 15-16.

[35] Personal communication by Julie Gorte, OTA, with William Hoffmeier, Agricultural Economist, Forest Products staff, U.S. Department of Agriculture, Foreign Agricultural Service, January 1983.

Other Far Eastern nations also levy tariffs that are generally higher on processed products than on raw materials.

Mexico, which is not a member of GATT, maintains strong protectionist measures and enforces high tariffs and import licensing requirements, with tariffs on forest products ranging from 10 percent on lumber to 70 percent on particleboard. Tariff barriers also tend to be strong in South America. Brazil, in order to protect its developing forest industry, maintains tariffs ranging from 45 percent on pulpwood logs to 160 percent on plywood. While some other South American tariffs are not as stringent as Brazil's, they are still high, and other import regulations often discourage wood product imports. Chile, with a 10 percent across-the-board tariff, maintains the lowest rates, but Chile is a net exporter of wood.

Nontariff Barriers

NTBs or distortions are growing in importance, but they are often difficult to identify. The effects of NTBs are equally difficult to measure, but there is little debate about whether they are potent hindrances to trade in forest products. Recent additions to GATT rules established some codes of conduct regarding some NTBs, but the new codes are not comprehensive and will be hard to enforce.

Some NTBs, such as product standards, have affected forest products exports significantly. Others have been less important, but may have more impact in the future as the use of NTBs expands. There are seven types of NTBs—quantitative restrictions, nontariff charges on imports, government intervention in trade, product standards, administrative practices, discriminatory ocean freight rates, and restrictions on export-related services.

Quantitative Restrictions

New-style quantitative restrictions or informal quotas on trade take many forms and have become more popular in recent years. The most frequently used types are new forms of quotas, embargoes, orderly marketing agreements, and voluntary export restraints. For forest products, many countries use embargoes, particularly to protect domestic resources and processing industries. Indonesia, Malaysia, and the Philippines place major restrictions on exports of hardwood logs in an effort to conserve stocks. The United States does not permit exports of logs harvested from National Forest System land or the substitution of National Forest System logs for exported logs produced from private lands.

Nontariff Charges on Imports

Nontariff charges on imports often take the form of taxes levied at various points in the product's distribution channel. Both Western Europeans and the Japanese levy value added taxes. In Sweden and Norway, where tariffs are fairly low, stiff value added taxes are levied on both domestic and foreign forest products.

Government Participation in Trade

Government participation in trade can involve countertrade (a form of barter), purchases by national enterprises or trading companies, and government procurement policies. None of these is a significant barrier to U.S. forest products exports at present, but countertrade in particular could become much more important in the future. Countertrade consists of agreements, usually between nations, to purchase certain quantities and types of products from each other. These arrangements are becoming much more common in East-West trade, and many Communist countries prefer countertrade arrangements to other types of trade. A countertrade agreement between Japan and the Soviet Union includes the exchange of Japanese construction machinery for Siberian timber. The Chinese have shown a preference for countertrade as well and may want to link future imports of forest products to exports of Chinese goods. The Japanese and Western Europeans have been willing to engage in countertrade agreements with Communist nations, while the United States has not. Since countertrade agreements often freeze out other suppliers, increasing use of this technique could deter U.S. exports of solid wood and pulp and paper products.

Product Standards

Health, safety, and other product standards often limit imports, although not all product standards are developed and used specifically to block imports. This type of NTB is particularly important in forest products. Standards can inhibit trade in many ways. Some are difficult or expensive for foreign producers to meet; some countries enforce standards, but do not publish them. Some change standards frequently, creating uncertainty for foreign producers interested in exporting. Finally, some standards are simply interpreted in arbitrary ways. The Japanese generally are acknowledged to use product standard barriers much more frequently than most other nations.

Plywood is one of the U.S. products most adversely affected by current standards. For example, German standards on preservatives restrict the types of plywood that are imported from the United States. Japanese standards for plywood knots, adhesive strength, and "white pockets"—fungus remnants in Douglas-fir plywood—have dampened U.S. plywood sales. These standards recently have been loosened, but they still may limit U.S. plywood exports to Japan. Significant reduction of these plywood trade barriers could benefit substantially both Pacific Northwestern and Southern producers.

Standards also are troublesome for U.S. paper producers. EEC has agreed, under the Multilateral Trade Negotiations, to reduce tariffs on kraft linerboard, but will not apply the reduction if the product contains 20 percent or more hardwood pulp. Most U.S. linerboard currently meets this ceiling, but industry trends have led to greater use of hardwood pulp. As a result, this standard may be more restrictive in the future.

Administrative Practices

The rules that a country establishes can act as barriers to trade, as can the way these rules are implemented and enforced. The most common types of administrative practices that can hinder trade include arbitrary methods of customs valuation, arbitrary product classification, inspection procedures, and licensing procedures. These barriers, which are used by nearly all nations, undoubtedly affect forest products trade. Mexico, for example, recently imposed new licensing requirements which effectively reduce imports of U.S. paper products. Recent revisions to GATT include codes on customs valuation, product classification, and import licensing procedures, but the details of these rules are not yet developed and their eventual impact is unknown.

Ocean Freight Rates

One-way ocean freight rates for certain commodities usually are set by conferences of nations. Many U.S. producers maintain that these rates discriminate against them. In fact, the American Paper Institute lists higher U.S. shipping costs as a disincentive to exporting certain grades of paper, particularly printing, writing, and specialty papers.[36]

Recent proposed changes in the regulation of ocean-liner conferences also concern U.S. paper producers. The 98th Congress is considering legislation that would largely exempt ocean-liner conferences from antitrust laws and which, if enacted, might result in significantly higher shipping rates in the view of some U.S. analysts.

Restrictions on Export-Related Services

Exporters require a broad range of services if they are to market their products successfully in overseas markets. Many countries have barriers against American banks and insurance companies and also may limit the ability of foreign firms to get local financing and insurance. While these barriers do not necessarily discriminate against any particular country or product, their existence may inhibit U.S. exports of solid wood and paper products.

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[36] "The American Paper Industry: An International Profile," op. cit., p. 10.

Other Factors Affecting Exports of Wood Products

Tariffs, quotas, and NTBs undoubtedly curb the ability of U.S. producers to export solid wood and pulp and paper products, but, while removal of these distortions would alter the nature of international commerce, the most dramatic stimulus to trade would be the improvement of the global economy. In all, there are five important factors that affect the volume and type of products traded—global economic conditions, currency exchange rates, private business attitudes, government policies that hinder exports, and government assistance to exporters.

Global Economic Conditions

In recent history, it has become increasingly difficult for nations to maintain separate economic identities. One-seventh of all U.S. jobs now depend on exports, and the situation is similar in most of the world's developed economies. The current global recession has damaged nearly all segments of the wood industry (although exports of most paper products have performed remarkably well under such adverse conditions) and has probably hurt U.S. wood exports far more than have NTBs. Economic recovery is likely to stimulate offshore demand for U.S. forest products much more than the removal or reduction of any trade barrier, although this is not meant to minimize the importance of efforts aimed at easing those barriers.

The recession is complicated further by the world financial situation. High interest rates, largely a function of U.S. monetary and fiscal policy, mean that Third World countries heavily in debt are having serious problems refinancing those debts. Many are turning for help to the International Monetary Fund, which will impose austerity programs in return for financial assistance. While this makes a certain degree of sense, it also makes it harder for these countries to import goods or to stimulate their own economies. It also makes it more difficult for U.S. producers to penetrate these markets.

Currency Exchange Rates

The value of the dollar relative to other currencies affects the prices and competitiveness of American goods overseas. For the past few years, the dollar has been very strong on world markets, rising sharply against the yen, the deutsche mark, and the franc between June 1980 and November 1982. Although it has fallen slightly since then, the dollar still is highly valued, particularly against the yen, considering the U.S. trade deficit with Japan.

The dollar is likely to remain strong as long as U.S. interest rates are significantly higher than foreign interest rates. Prolonged balance-of-payments deficits in the United States ordinarily would lead to devaluation of the dollar against other currencies, but this has not happened. High interest rates in the United States and the huge Eurodollar market have overwhelmed other currency adjustments, and, until these adjustments are made, U.S. exporters will have a disadvantage on world markets. U.S. interest rates are particularly high compared with those in Japan, which keeps its own interest rates low by preventing foreign entry into Japanese financial markets.[37]

Private Business Attitudes

World perceptions of private U.S. business attitudes can have a major impact on trade. Until recently, the U.S. forest products industry was believed to be somewhat unreliable or unwilling to make long-term commitments that many importers want. According to one analysis, the U.S. forest products industry has never made a concerted effort to export its products, but is now beginning to see offshore markets as a strategy for survival.[38] Responding primarily to the enormous demands of the domestic market for forest products, the industry has tended to view exports as something to do with its products during downturns in the business cycle,[39] and has gained a reputation for losing interest in offshore customers when domestic demand picks up. In part, foreign protectionist practices limit imports of U.S. products, especially during downturns, but the reputation of U.S. producers still persists.

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[37] Norman Gall, "Black Ships Are Coming?" *Forbes*, Jan. 31, 1983, p. 75.

[38] Kathleen K. Wiegner, "Forest Products," *Forbes*, Jan. 3, 1983, p. 110.

This "American Market Syndrome" is changing. The National Forest Products Association, representing a large portion of the Nation's solid wood products sector, has launched a cooperative effort to develop foreign markets for lumber, plywood, and panels with the U.S. Department of Agriculture's (USDA) Foreign Agricultural Service (FAS). The project largely involves working with foreign governments in removing or reducing NTBs to trade in solid wood and promoting the use of U.S. wood products abroad. Over the last three decades, FAS has had an excellent record in promoting agricultural exports and its success bodes well for the future of exports of solid wood products.

A key element in U.S. producers' establishing their reliability as world suppliers of forest products is their performance when domestic demand rises. The commitment of these producers to foreign markets has yet to be fully tested. As the U.S. economy recovers and domestic demand for wood products increases, the behavior of U.S. firms that have expressed interest in foreign trade will be watched carefully.

Government Policies That Hinder Exports

Government as well as industry shapes world perceptions of the United States an unreliable trading partner. Increasing willingness by the U.S. Government to use export controls—embargoes, sanctions, and other export bans—has hurt U.S. producers. While the Federal Government has not applied trade sanctions specifically in forest products, its readiness to use them as an instrument of foreign policy (or as a weapon) probably has harmed all U.S. exporters to some degree.

Taxation of foreign earned income also may hamper the ability of U.S. producers to promote products overseas. The United States is the only major industrial country that taxes on the basis of citizenship rather than residence. Nationals of other countries generally are taxed only in the country where they live. Because American citizens must pay U.S. taxes on income earned abroad, it is very expensive for U.S. companies to keep American executives overseas, and to maintain marketing support in foreign countries.

Uncertainty over the interpretation of the Foreign Corrupt Practices Act may also hinder exports.

Government Assistance to Exporters

Several U.S. Government agencies affect trade policies and offer assistance to exporters. They include:

- the Office of the U.S. Trade Representative, a cabinet-level official who represents the United States in both GATT and bilateral trade negotiations;
- the Department of State, which is involved in trade negotiations;
- the Department of Commerce, which maintains the Foreign Commercial Service and otherwise assists U.S. exporters and which also administers export controls;
- USDA, which maintains FAS, now assisting wood products exporters;
- the Department of Treasury, which helps set international economic and monetary policy;
- the National Security Council and the Department of Defense, both of whom play an active role in policies on export controls; and
- others who provide assistance, including the Export-Import Bank, the Small Business Administration, the Overseas Private Investment Corporation, and USDA's Commodity Credit Corporation.

As noted, FAS recently has been authorized to help solid wood products exporters. However, there is no comparable assistance at present available to U.S. paper producers. The Foreign Commercial Service, while it is empowered to provide this service, is organized along regional rather than commodity lines and probably is unable to provide the type of export assistance offered by FAS. While there is no legal restraint on FAS offering assistance to U.S. paper producers, the agency is currently too understaffed both in the United States and abroad to provide this additional service. Nevertheless, the paper industry has shown little interest in FAS assistance to date.

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[39] *Increased Wood Products Exports,* op. cit., p. 3.

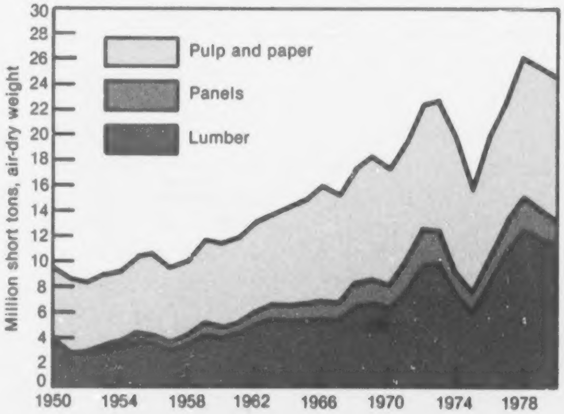
The U.S. Government does not provide the level of export assistance that some other governments do. Assistance from the U.S. Trade Representative and the Departments of Commerce and Agriculture are available, but no agency provides the kind of comprehensive information and assistance given, for example, by the Japan External Trade Relations Organization (JETRO). Generally, the U.S. Government does not confer direct export subsidies that would be acceptable within the GATT framework. More common than direct financial assistance are certain forms of tax assistance. One such program, the Domestic International Sales Corporation (DISC), provides special subsidies for export sales that allow corporations to defer some taxes. This program has been found illegal by a GATT tribunal under the Tokyo Round subsidies code, and the Reagan administration has committed itself to a reappraisal of the program as a result. Abolition or dilution of DISC, according to the American Paper Institute, could hinder future plans for exports.[40]

Another program that can aid U.S. producers in expanding exports is a new law allowing American firms, including banks, to form export trading companies. It is intended to help small and medium-sized companies band together in order to export. Certain exemptions from current antitrust law may permit new forms of cooperation, but it is too early to assess the impact of this program.

U.S. Imports of Forest Products

The tonnage of U.S. imports of forest products has increased over 250 percent since 1950 (fig. 7). The constant (deflated) value of wood imports has increased by 75 percent since 1964 (fig. 8). While the United States has been a net importer of forest products for at least 20 years, the balance-of-payments deficit has narrowed sharply. In 1979, the deficit was over $2.6 billion, but dropped to less than $1.7 billion in 1982. In 1982, for the first time in recent history, the United States became a net exporter of solid wood products (roundwood, sawwood, and panels), primarily because the value of imports dropped more than the value of U.S. exports during the recent recession.[41] The United States remained a net importer of pulp and paper, although the trade deficit in pulp and paper dropped by more than $400 million.

Figure 7.—Tonnage of U.S. Wood Imports, by Product, 1950-79



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, December 1982), pp. 302-303.

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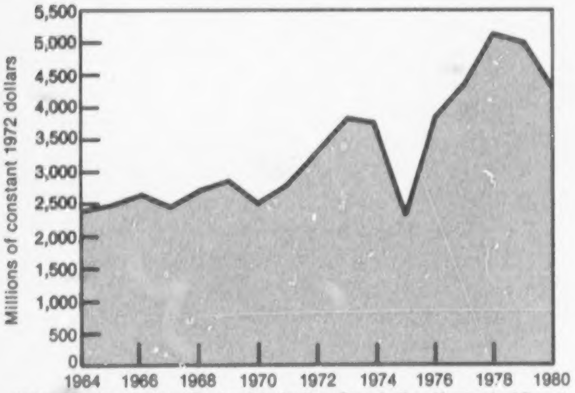
[40] "The American Paper Industry: An International Profile," op. cit., p. 8.

[41] U.S. Department of Commerce, International Trade Commission, unpublished data, 1983.

Figure 8.—Value of U.S. Wood Products Imports, 1964-80



SOURCE: United Nations Food and Agriculture Organization, *Yearbook of Forest Products, 1975* (Rome: FAO, 1977), p. 301.

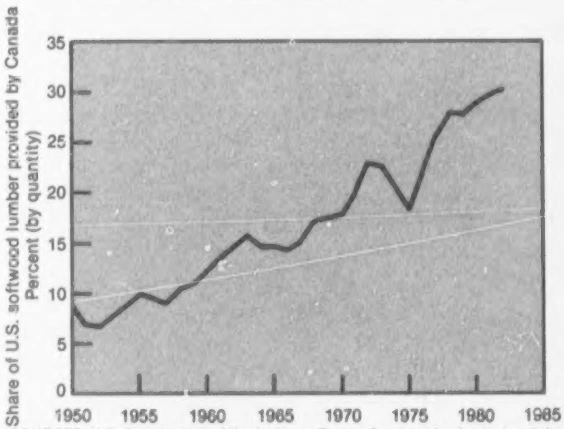
Solid Wood Products

In 1982, the value of U.S. imports of solid wood products* totaled nearly $2.3 billion, down from over $3.5 billion in 1979, with almost 70 percent of 1982 imports of solid wood products consisting of softwood lumber from Canada (table 8). For over 30 years, imported Canadian lumber has accounted for a growing share of the volume of U.S. lumber consumption, rising from less than 7 percent in the early 1950's to over 30 percent in 1982 (fig. 9), although the tonnage decreases during downturns in U.S. homebuilding activities.

The current recession has caused the volume of all imported lumber to drop from 11.6 billion board ft in 1978 to 8.9 billion board ft in 1982. Declining lumber imports between 1981 and 1982 accounted for over 70 percent of the total decrease in U.S. imports of solid wood products.

The U.S. probably will continue to be a major importer of solid wood products. No sig-

Figure 9.—Relative Importance of Canadian Softwood Lumber Imports, 1950-82



SOURCES: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: Forest Service, December 1982). National Forest Products Association, personal communication. International Trade Commission, personal communication.

Table 8.—U.S. Imports of Solid Wood Products, 1982

Product	Quantity (mbf[a])	Value (thousands of dollars)	Percent of total value
Logs and timber	117,032	$26,430	1.2%
Hardwood	18,268	3,500	0.2
Softwood	98,764	22,930	1.0
Pulpwood (including chips)	NA	56,248	2.5
Wood waste, fuel	NA	8,446	0.4
Lumber and railroad ties	9,200,075	1,665,312	73.2
Softwood lumber	8,973,652	1,567,931	68.9
Other	226,423	97,381	4.3
Wood-based panels	NA	519,585	22.8
Hardwood veneer and plywood	NA	402,798	17.7
Other	NA	116,787	5.1
Total		$2,276,021	100.0%

[a] mbf = million board feet.

SOURCE: U.S. International Trade Commission.

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*Logs and timber, pulpwood (including chips), wood wastes and fuels, lumber and railroad ties, and wood-based panels.

nificant changes in patterns of U.S. imports are foreseen,[42] although the declining availability of tropical veneer species from Southeast Asia may limit U.S. hardwood imports before the end of the century.

Pulp and Paper Products

In 1982, the United States imported woodpulp and paper products worth $5.3 billion, and its balance-of-payments deficit in these products was over $1 billion, considerably less than in 1979 when net imports were over $1.4 billion. Imports of fine papers (mainly newsprint) accounted for over 60 percent of U.S. pulp and paper imports in 1982, and woodpulp accounted for almost 30 percent (table 9). About 90 percent of all pulp and paper imports came from Canada.

No major changes in the patterns of U.S. imports of pulp and paper are expected. Although the United States also is exporting increasing amounts of woodpulp and paper, many States of the Northeast, the Great Lakes, and the Midwest are deficient in softwoods needed to manufacture newsprint. The proximity of Quebec and Ontario, with large softwood resources, gives Canadian producers advantages in exporting these products to needy U.S. markets.

Table 9.—U.S. Imports of Pulp and Paper Products, 1982

Product	Quantity (st[a])	Value (thousands of dollars)	Percent of total value
Woodpulp	3,656	$1,493,241	28.1%
Paper products	NA	3,826,595	71.9
Waste paper	132	24,291	0.5
Building paper	187	44,099	0.8
Industrial Paperboard	76	23,173	0.4
Fine papers	NA	3,328,696	62.6
Miscellaneous[b]	NA	406,336	7.6
Total		$5,319,985	100.0%

[a]st = short tons.
[b]Industrial papers, packaging, and miscellaneous paper.
SOURCE: U.S. International Trade Commission.

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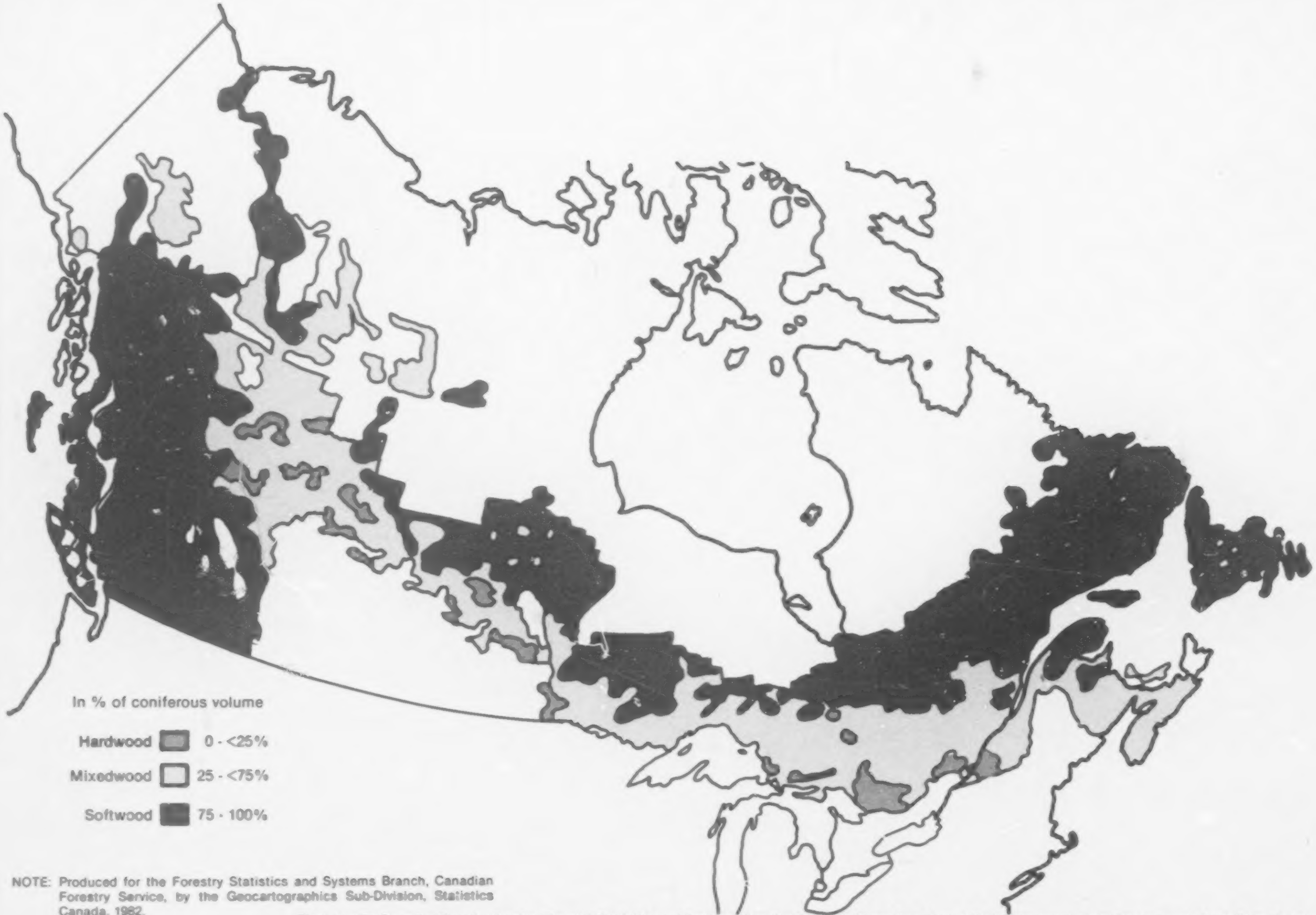
[42] *Analysis of the Timber Situation*, op. cit., p. 102.


In % of coniferous volume
Hardwood ▨ 0 - <25%
Mixedwood ☐ 25 - <75%
Softwood ■ 75 - 100%

NOTE: Produced for the Forestry Statistics and Systems Branch, Canadian Forestry Service, by the Geocartographics Sub-Division, Statistics Canada, 1982.

Photo credit: Canadian Forestry Service, Forestry Statistics and Systems Branch, "Canada's Forest Inventory, 1981." Department of the Environment, Chalk River, Ontario

Canada's softwood forests are well located to satisfy many Northeastern U.S. wood markets

CHAPTER IV

Wood Use in the United States

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CHAPTER IV

Wood Use in the United States

Summary

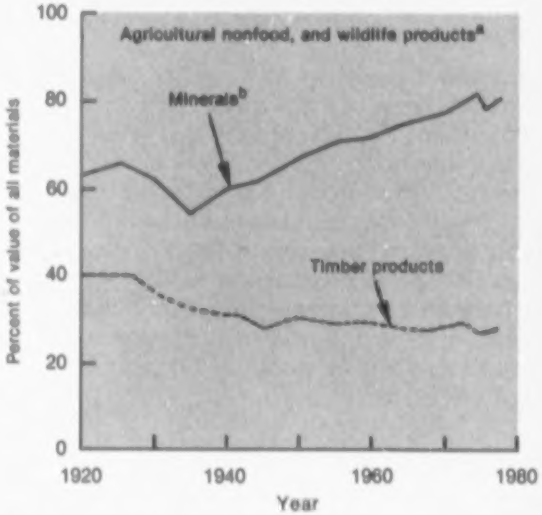
Americans currently consume about one-fourth of the world's forest products and have the highest per capita consumption in the world. At the same time, the United States is the world's largest producer of wood products, accounting for about 35 percent of total global output of paper, 45 percent of all plywood, and 20 percent of softwood lumber.[1]

While the contribution of wood to the domestic economy has been declining over the past 50 years (fig. 10), it continues to be valuable in construction, shipping, packaging, and communications. Wood's future role in the national materials mix is difficult to forecast, but wood should continue to be an important raw material in the foreseeable future. Whether its contribution to the economy expands or decreases will depend on several factors:

- the relative availability and price of wood compared to alternative materials,
- technological advances affecting uses for wood and other materials,
- the business acumen of the forest products industry compared to its competitors,
- government policies that encourage or inhibit use of wood relative to other materials, and
- consumer preferences.

Wood is made into thousands of products, but a few uses dominate today's market. Once again, after a period of decline, energy is the highest volume use for wood in the United States. Over half of the wood removed from forests in the early 1980's ultimately was burned for energy. Much of this consisted of pulpmill wastes, but a growing percentage was fuelwood used for residential heat and commercial power.* The forest products industry, which uses waste wood and residues for fuel, accounts for about 65 percent of wood energy use, while the remaining 35 percent is burned for home heating. Future levels of fuelwood use are difficult to predict; however, **continued but probably slower growth in residential and commercial use of wood energy is likely in the Eastern United States for at least the next decade.**

Figure 10.—Relative Importance of Industrial Raw Materials, 1920-77



[a]Includes cotton and other fibers, oils, rubber, furs, hides, and other similar products.
[b]Includes mineral construction materials, metal ores, chemical and fertilizer materials, abrasives, and other minerals.

SOURCE: U. S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 3.

Over half of the solid wood products consumed, including lumber and plywood and other panels, are used in construction, mostly single-family housing. After World War II, a trend toward building large detached homes developed and increased the demand for wood, even though construction methods became more efficient. In the future, growth in housing and related demand for wood may slow due to the higher cost of homeownership, shrinking household size, and possibly an increasing proportion of multifamily dwellings.

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[1] Roger Sedjo and Samuel Radcliffe, *Postwar Trends in U.S. Forest Products Trade*, Resources for the Future Research Paper R-22 (Washington, D.C.: Resources for the Future, 1980), p. 595.

*Wood consumption for other forest products decreased in 1981 because of the economic recession while fuelwood consumption continued at a high rate.

Demand for pulp and paper products has grown dramatically in recent decades, and prospects are good for continued growth. However, paper products face increasing competition from other materials, particularly plastics. Electronic communications may alter paper consumption patterns in the future, but the magnitude and direction of possible shifts are uncertain. The immediate effect of computers, word processors, and office copying equipment has been to increase demand for some types of paper.

Forest products have a variety of uses in manufacturing, shipping, and heavy industry. With the exception of pallets, demand for major industrial products made from wood have either leveled off or declined as usage has changed or as other materials have replaced wood. Nevertheless, wood will continue to be valuable for a wide range of minor industrial and specialized applications.

Chemicals and cellulosic fibers are also produced from wood. The $1.5 billion cellulosic fiber industry, which makes rayon and acetate, uses refined wood cellulose as a basic raw material. Over $500 million in other silvichemicals are also produced from wood each year. These silvichemicals include lignin byproducts, food additives and flavorings, and naval stores. Wood also can be used to make many products now made with petrochemicals. Production of chemicals as byproducts of wood manufacturing probably will continue, but widespread replacement of chemicals now made from petroleum is unlikely. However, intensified research on wood chemicals, particularly lignin, could lead to new products of considerable value.

Although the United States is the world's largest producer and consumer of wood products, with demand increasing since 1950, wood's importance to the domestic economy has declined. The value of timber products as a proportion of the value of all industrial raw materials has been dropping for more than 50 years, from about 40 percent of the total in 1920 to about 27 percent in 1977. In part, this is because some traditional uses for wood have decreased in importance and because nonrenewable products, such as plastics and metals, are competing successfully in forest products markets. The rising value of nonrenewable raw materials may be other factors accounting for the decline. **An expanding role for wood in the economy is possible if the price and availability of nonrenewable materials become less competitive. Otherwise, industrial uses for wood are not likely to expand significantly.**

Wood's future also may depend on the development of new wood products to compete with nonwood products as well as the development of composites that combine wood and nonwood materials. For example, new wood building materials are available which could expand current wood markets or open others in the coming years. New super-strength paper and paperboard products, currently in developmental stages, also could have some structural applications. Composite materials made of wood in combination with fiberglass, plastics, or metal have demonstrated superior performance for some applications, but currently are not widespread in use.

In 1980, the Forest Service issued projections of future timber demand, supply, and consumption as part of an assessment process required by the Forest and Rangeland Renewable Resources Planning Act of 1974. These projections, which are the basis for many Forest Service timber management programs, show rapidly rising timber consumption in the next 50 years, accompanied by rising timber prices and declining softwood timber inventories after 2010.

According to the projections, timber consumption from domestic forests will rise from over 12 billion cubic feet (ft^3) in 1976 to nearly 23 billion ft^3 in 2030. Consumption of hardwoods is expected to rise somewhat faster than consumption of softwoods. Hardwood consumption, which accounted for less than one-third of the 1976 timber harvest, is expected to reach nearly 40 percent by 2030.

Another change shown in the projections is a substantial shift of harvest from the Pacific Northwest to the South. The South's share of the softwood harvest is projected to increase from 45 percent in 1976 to 53 percent in 2030, and its share of the hardwood harvest from 51 to 59 percent during the same period. Recent data, however, shows larger inventories and faster growth in the Pacific Northwest than the older data indicate, a difference that probably will dampen the regional shift.

The 1980 projections may overstate future timber consumption and price rises due mainly to possible overestimates of demand and underestimates of timber growth. The large projected increase in timber demand in the future stems primarily from assumptions about economic activity, housing starts, and home characteristics that many analysts think are too optimistic. Future timber supply estimates are based on static forest management and short-term supply assumptions that probably understate future growth potential. However, because projections of southern softwood inventories are being revised downward to conform with more recent survey information, the future supply picture is somewhat uncertain. Underestimates of future supply also may be offset somewhat by possible overestimates of commercial timber acreage.

The forest products industry employs almost 2 percent of the Nations's full-time work force and contributes almost 2 percent of the gross national product (GNP). The industry contains two major sectors: 1) pulp and paper, and 2) lumber and panels (solid wood). The lumber and panels sector employs more people than does the pulp and paper sector, but pulp and paper contributes a higher value added.

Historically, primary processing operations, including logging, lumber and panel manufacture, pulping, and papermaking have been concentrated where inventories of raw materials are greatest, mostly near the abundant softwood forests of the Pacific coast and the South. Secondary processing (the manufacture of goods such as boxes, cartons, paper products, trusses, and furniture) tends to be located closer to markets, mainly in the Eastern United States.

The financial performance of the forest products industry has been roughly equal to that of other industries over the long term. However, in periods of recession, the lumber and panel products sector has been particularly vulnerable because of its heavy dependence on highly cyclical homebuilding activity.

The forest products industry is fairly competitive, but there are several leading companies. In 1978, the top four firms accounted for nearly 15 percent of sales. One of the major factors that appears to correlate with industry dominance is landownership. The top 40 firms in sales own 80 percent of all forest industry land, which totals 68.8 million acres or about 14 percent of all U.S. commercial forestland. Another factor associated with industry leadership is diversification. The largest firms often produce both paper and solid wood products, while smaller firms are more likely to specialize. Neither landownership nor diversification, however, is necessarily a determinant of industry dominance.

History of Wood Use[2]

Wood is probably the most versatile of all materials, adaptable to a broad range of uses and functions (table 10). For millenia, wood in its most rudimentary forms—firewood and logs—provided humanity with fuel, water transportation, shelter, and food. Ancient peoples invented ways to extract natural chemicals from it, such as resins, oils, and medicines. The basics of producing paper were known to the Chinese by the first century A.D., and similar processes, developed separately, apparently were known to the Mayas and Incas. In the 19th century, papermaking machines became common in Europe and the United States, enabling high-volume production. Wood's abundance or scarcity among nations has been a contributing impetus to warfare for hundreds of years. For example, colonial resentment of Britain's earmarking of "crown timbers" for shipbuilding is said to have exacerbated tensions leading to the American Revolution.[3] Other instances have occurred as recently as World War II.[4]

Table 10.—Representative Uses for Wood

Uses/Examples
Construction:
Residential housing construction and upkeep, mobile homes, and light commercial structures; arches and beams for sports arenas, convention centers, etc.
Communications:
Newsprint, printing papers, and other paper products
Packaging:
Bags, sacks, containers
Furniture manufacturing:
Household and commercial furniture
Shipping:
Pallets, containers, dunnage, blocking, and bracing
Transportation:
Railroad ties, manufacture of railroad cars, boats, and light airframes
Wood fuel:
Fuelwood, woodchips, mill residues, etc.:
Residential home heating and cooking, forest products industry process energy, electricity generation
Liquid and gaseous fuels:
Potential supplement for petroleum and natural gas as a fuel or alternative petrochemical feedstock
Chemicals and cellulosic fibers:
Rayon and cellulose acetate:
Clothing fibers, tires, conveyor and transmission belts, ribbons, films, etc.
Silvichemicals (naval stores and pulping byproducts):
Used in production of synthetic rubber, chewing gum, rosin bags, inks, adhesives, paints, soaps, detergents, solvents, odorants, bactericides, drilling mud thinners, dispersants, leather tanning agents, water treatment, pharmaceuticals, etc.
Food and feed products:
Feed molasses, animal fodder, vanillin flavoring, food grade yeast products
Miscellaneous and specialty products:
Utility poles, pilings, fencing, mine props, cooperage, activated carbon, sporting goods, musical instruments, pencils, caskets, signs and displays, etc.

SOURCE: Office of Technology Assessment.

The extensive forests of colonial America were considered to be an obstacle to agriculture and settlement. Nonetheless, the superabundance, low cost, and workability of wood permitted its easy substitution for more suitable, durable, and as-yet unavailable but scarcer materials for shelter, transportation, and tools. The U.S. industrial revolution depended on wood for fuel and tools until fossil fuels, iron and steel replaced it.

Wood was the most important source of energy in the United States a century ago, providing an estimated two-thirds of industrial and residential fuel needs. When the advantages of fossil fuels to an increasingly urbanized and industrialized society became obvious, wood fuel use began to decline, both in proportion to total energy use and in absolute quantities. It recently has increased again as a way to beat rising energy prices.

Wood served an important but temporary function in the development of the early U.S.

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[2] Information on the history of wood use can be found in Robert L. Youngs, "Every Age, the Age of Wood," *Interdisciplinary Science Reviews*, vol. 7, No. 3, 1982, pp. 211-219; and in Elgon Glesinger, *The Coming Age of Wood* (New York: Simon & Schuster, 1949).

[3] As discussed in Robert F. Albion, *Forests and Sea Power: The Timber Problem of the Royal Navy* (Cambridge, Mass.: Harvard University Press, 1926), pp. 231-280.

[4] The role of wood in World War II is discussed in Elgon Glesinger, *Nazis in the Woodpile: Hitler's Plot for Essential Raw Material* (Indianapolis and New York: Bobbs-Merrill, 1942).

network of roads, bridges, and railroads.[5] In some areas, wooden roads were formed by laying logs in a corduroy pattern; planks or wood blocks also served as road pavement. The tracks, not just the ties, of early railroads were built of wood. In 1910, at the high point of railroad expansion, an estimated one-fourth of all wood consumed in the United States was for railroad ties.[6]

Advances in technology over the past 100 years have resulted in many new wood products (table 11), a variety of reconstituted structural wood products, and composite products that join wood with other materials to improve its strength. Many of these products have comparable or superior performance to lumber, yet allow fuller recovery of the resource. Much of the paper and paperboard now produced in this country is made from southern pine species, which were considered unsuitable for papermaking before adaptation of the kraft sulfate process in the 1930's. Now, hardwoods are used increasingly throughout the industry as technology expands to take advantage of these cheap and abundant materials.

Table 11.—Taxonomy of Major Forest Products

Product	Description	Status of lifecycle	Major end use
Lumber type products			
Boards[a]	1″ thick, 4″ to 16′, > 1″ wide	M	General purpose
Dimension[a] lumber	2″ to < 5″ thick, > 2″ wide, usually 4′ to 16′ long solid wood, sometimes edge glued	M	Structural framing
Timbers	5+′ thick, > 4″ wide, various lengths; solid or laminated wood	M	Structural framing beams, and large supports
Parallel laminated veneer (PLV)	Usually same dimensions as lumber and timbers, made from wood veneers laminated with parallel grains	G	Structural framing and supports. Can also be used in millwork and molding
Utility poles	9″ to 14″ diameter, 50′ to 80′	M	Transmission lines
Panel type products			
Plywood	Flat panels, usually 4′ × 8′, less than 1.5″ thick, made from wood veneers laminated with grains of adjacent veneers perpendicular. Usually 3 to 5 plies (veneers)	M	Structural sheathing, flooring, and a variety of semistructural uses
Hardwood	Flat panels made of individual wood fibers, usually glued together	M	Floor underlayment, facing for architectural concrete, wall linings, door inserts, stereo, radio and TV cabinetry, and furniture
Particleboard	Flat panels, less than 1.5″ thick, cut to size of 4′ × 8′, composed of very small wood particles glued together	M	Underlayment, furniture core
Medium-density fiberboard	Same as hardboard, with extremely flat, smooth surface and edges	M	Furniture, wall siding
Semirigid insulation board	Flat panels made of individual wood fibers, usually loosely matted, fibers bonded by interfelting	D	Insulation, cushioning
Rigid insulation board	Same as semirigid insulation board	D	Interior walls and ceilings, exterior sheathing
Waferboard	Flat plywood-like panels made with flat, nonalined wafers or large chips of wood glued and pressed together	G	Paneling, substitute for plywood in structural use, wallboard
Oriented strand board (OSB)	Flat plywood-like panels made with aligned strands or ribbon-shaped pieces of wood. Sometimes crossbanded (strands in different layers oriented perpendicular to adjacent layers), sometimes veneered	G	Same as plywood
Com-Ply	Flat plywood-like panels or lumber-like pieces, with particleboard cores and wood veneer faces	B	Same as lumber and plywood

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[5] See Don H. Berkebile, "Wooden Roads," Lee H. Nelson, "The Colossus of Philadelphia," and John H. Nelson, "Railroads: Wood to Burn," in *Material Culture of the Wooden Age*, Brooke Hindle (ed.) (Tarrytown, N.Y.: Sleepy Hollow Press, 1981), for a discussion of wood's role in early U.S. transportation.

[6] Glesinger, *The Coming Age of Wood*, op. cit.

Table 11.—Taxonomy of Major Forest Products (continued)

Product	Description	Status of lifecycle	Major end use
Paper products			
Unbleached kraft paper	Brown, somewhat coarse, stiff paper manufactured primarily by the kraft sulfate process from hardwoods and softwoods	M	Heavy packaging, bags, and sacks
Bleached kraft paper	White fine textured paper manufactured by either the kraft sulfite process or the kraft sulfate process from either softwoods or hardwoods. The better papers are provided from softwoods	M	Fine writing and printing papers and paperboard for packaging
Newsprint and groundwood printing papers	Coarse textured paper of low strength and limited durability, which tends to yellow with age. It is manufactured from mechanical and semimechanical (particularly chemically treated) pulp, which uses either hardwoods or softwoods	M	Printing of newspaper and for other printing uses not requiring durability
Corrugating medium	Coarse, low-strength paper produced primarily from sulfite pulping of hardwoods	M	Corrugated boxes as dividers and stiffeners between the paperboard liners
Linerboard	Stiff, durable, thick paper made primarily from unbleached kraft paper made by the sulfate process	M	Heavy duty shipping containers and corrugated boxes
Paperboard	Stiff paper of moderate thickness made primarily from bleached sulfate kraft pulp	M	Milk cartons, folding boxes, and individual packaging
Coated paper	Printing papers that have been coated with materials that improve printability and photo reproduction	M	Magazines, annual reports, and books
Specialty papers	Diverse group of products ranging from thin filter papers to stiff card stock	M	Cigarettes, filter papers, bonded papers (with cotton fibers) index cards, tags, file folders, and postcards
Tissue paper	Thin, soft, absorbent papers manufactured primarily from chemical groundwood pulps	M	Toweling, tissues, and hygenic products
Other products			
Rayon	Synthetic fiber produced by the viscose process using pure cellulose produced by the dissolving pulp process. Rayon has properties similar to cotton	M	Woven cloth as a cotton substitute
Acetate	Synthetic fibers produced from dissolving pulp-like rayon, but further chemical treatment make them water resistant with properties more like nylon or orlon	M	Woven cloth as a substitute for nylon and other petroleum-derived synthetic fibers
Cellulosic films	Film made from dissolving pulp by the rayon and acetate processes, but extruded as sheets of various thicknesses	D	Packaging (cellophane) protective coverings, photographic applications, transparent drafting and graphic materials

NOTE: B = beginning; G = growing; M = mature; D = declining.
[a]Nominal dimensions, i.e., 1" nominal = 3/4" actual.

SOURCE: Office of Technology Assessment.

Uses of Wood

Wood for Energy

Since the 1973 oil embargo, wood has reemerged as an important domestic source of energy. Energy extracted from wood in 1981, including milling and pulping wastes, represented more than half of all wood removed from U.S. forests that year. Wood fuel is used primarily by the forest products industry, which meets a high proportion of its energy needs by burning wood wastes, and by homeowners for residential heating. The potential of wood as an energy source is analyzed in the 1980 Office of Technology Assessment (OTA) report, *Energy From Biological Processes.*[7] New information on wood energy use recently became available, due to independent surveys conducted by the Department of Energy (DOE) and the Forest Service. Both the DOE survey and the preliminary Forest Service survey show that residential fuelwood use is far greater than previously reported.

Over 130 million dry tons (1 dry ton = 1 cord) of wood were burned for fuel in 1980, according to a DOE survey.[8] This tonnage represents about 2.2 quadrillion Btu (2.2 Quads) of energy—about 3 percent of total domestic energy consumption.[9] On the basis of the more conservative Forest Service estimate of residential fuelwood use, OTA estimates that about 55 percent of all wood removals in the United States in 1980 were consumed for fuel purposes (table 12).*

About 60 percent (81 million short tons) of all wood energy was used by the forest products industry in manufacturing. The remaining 42 million to 48 million short tons were used primarily for residential home heating.

Prospects for Further Growth in Wood Fuel Use

Since the forest products industry already derives a large percentage of its energy requirements from wood, the areas where wood fuel use grows the most in the future probably will be in residential and commercial (e.g., hospital and nonwood manufacturing) applications.

In contrast to wood fuel byproducts used by the forest products industry, residential fuelwood use almost always involves removal of

Table 12.—OTA Calculations of Wood Fuel Removals, 1980

1980 quantitites of wood removed	Million tons of oven-dried wood
Wood (bark excluded) for forest products industry (estimated at 11.6 billion cubic feet)	160
Bark portion of forest products industry removals	21
Residential fuelwood (quantity harvested for use in 1980-81 heating season: 42 million cords, at approximately 1 ton each)	42
Total 1980 quantity of wood removed	223

1980 wood fuel consumption	Quads	Million tons of oven-dry wood needed to produce the equivalent amount of energy
Industrial (including mill residues, and spent pulping liquors)	1.4	81
Residential	0.8	42
Total 1980 wood fuel consumption	2.2	123

NOTE: The ratio of the 1980 wood fuel consumption to the 1980 quantity of wood removed is 123/223 or 55 percent. This figure is based on very crude estimates and calculations and provides only a rough approximation of the importance of wood fuels. It furthermore is subject to wide fluctuations correpsonding to changes in annual removals of industrial roundwood. In 1981, for example, the ratio certainly increased, as removals declined and wood fuel consumption continued to increase.

SOURCES: *Estimates of U.S. Wood Energy Consumption From 1949 to 1981* (Washington, D.C.: U.S. Department of Energy, 1982), p. 95; Kenneth E. Skog and Irene A. Watterson, *Residential Fuelwood Use in the United States: 1980-81* (draft report), U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, March 1983, p. 1, p. 17, and table 4; conversation with Robert B. Phelps, Research Forester, Demand Price and Trade Analysis, Forest Resource Economics Research Staff, U.S. Department of Agriculture, Forest Service, May 26, 1983; letter from John G. Haygreen, Professor and Head, Kaufert Laboratory, Department of Forest Products, College of Forestry, University of Minnesota, to James W. Curlin, Project Director, Office of Technology Assessment, U.S. Congress, letter dated Nov. 1982; and conversations with Kenneth E. Skog, Research Forester, Engineering and Economics Research, U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wis.

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[7] *Energy From Biological Processes,* vols. I-III (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-E-124, 1980).

[8] U.S. Department of Energy, *Estimates of U.S. Wood Energy Consumption From 1949 to 1981,* stock No. 061-003-00266-8 (Washington, D.C.: U.S. Government Printing Office, August 1982).

[9] Derived from the U.S. Department of Energy, *Monthly Energy Review,* November 1982.

*In 1981 and 1982, the proportion of removals used as wood fuel probably exceeded 55 percent, due to continued growth in residential fuelwood use and a decline in forest products industry removals resulting from the economic recession.

wood from forests specifically for fuel. Many variables will influence trends in this area, including the abundance and accessibility of fuelwood, the relative price and availability of nonwood fuels, and personal preferences of homeowners. In the short term, all of these variables appear to favor increased fuelwood utilization, although probably not at the rapid rate of increase of the late 1970's.

Current residential fuelwood use is significantly above levels projected by the Forest Service in its 1980 assessment under the Forest and Rangeland Renewable Resources Planning Act of 1974 (Public Law 93-378). The projections said that residential fuelwood use would grow progressively from an estimated 6 million cords in 1976 to 26 million cords in 2030. Recently, however, the Forest Service revised its forecast to reflect new evidence of rapidly increasing consumption. The new forecasts, issued in a draft supplement to the 1980 supplement, show wood fuel use quadrupling within the next 50 years, reaching nearly 200 million cords annually. Much of this increase may reflect rapid growth in commercial use of wood fuels as well as residential fuelwood. While these projections cannot be made with certainty, it does seem probable that wood fuel use will significantly exceed the Forest Service projections made in 1980, even if it falls short of the revised estimates.[10]

Demographic and technological trends favor continued growth in fuelwood use for residential home heating, although probably at slower rates than in the 1970's. In forested regions, fuelwood is easily accessible to the increasing proportion of the population living in suburban and rural communities.

The availability of highly efficient wood burning stoves, inexpensive chain saws, and log splitters makes it possible for many rural and suburban residents to meet a high proportion of their home heating needs from nearby woodlands. In some instances, as in the case of national forests, firewood is provided at little or no cost to people willing to remove it. There has been a tenfold increase in firewood permits issued for national forests since 1971, representing a rise in wood removal from about 400,000 cords per year to about 4 million cords.* Other arrangements such as fuelwood purchasing cooperatives can reduce firewood costs below what individual purchasers must pay.

Increased wood fuel utilization by small nonwood industrial and commercial firms is also probable. Such firms currently account for a small portion of wood fuel consumption, but increasing numbers of companies in regions with abundant wood supplies find wood competitive with petroleum and natural gas fuels.[11] Wood also has certain economic advantages over coal, since wood boilers generally require lower capital investment for air pollution controls. Use of wood fuel in industrial processes and for electricity by public utilities is occurring in some areas.

Wood Fuel Use by the Forest Products Industry

Between 1972 and 1981, wood fuel use by the energy-intensive pulp and paper sector increased from about 40 to 47 percent of the total energy consumed by this part of the forest products industry. Wood fuel provided about 73 percent of the solid wood industry's energy needs in 1981.[12]

Because it already uses most pulping and mill residues, the forest products industry will find it more difficult to burn much more wood. Much of the remaining residues not burned for energy are used to make composite wood products or silvichemicals. Further increases in energy self-sufficiency may require the recovery of logging residues now left in the forests, harvesting of wood specifically for fuel use, and the development of more energy-efficient processing methods.

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[10] The initital estimate and forecast are contained in U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 67; the revised projections are contained in the Forest Service's *Review Draft: America's Renewable Resources: A Supplement to the 1979 Assessment of the Forest and Rangeland Situation in the United States*, preliminary draft subject to revision, Feb. 4, 1983, p. 15.

*Information on fuelwood removals from national forests provided by the Forest Service.

[11] See Charles E. Hewett and William T. Gladden, Jr., *Market Pressures to Use Wood as an Energy Resource* (Hanover, N.H.: Dartmouth College, Thayer School of Engineering and Resource Policy Center, June 1982) for regional prices of wood and other fuels on a Btu equivalent basis.

[12] National Forest Products Association, "Industrial Energy Conservation Program 1981 Report for Lumber and Wood Products" (Washington, D.C.: National Forest Products Association, June 24, 1982).

To date, nearly all wood energy is derived from the direct combustion of wood and wood byproducts. Wood also can be gasified or converted to liquid alcohol fuels that could substitute directly for fossil fuels. Several small-scale technologies for wood gasification are commercially available at this time although the Btu content of the gas is low. To date, no commercial facilities to produce alchohol fuels from wood have been constructed. One technological barrier to commercialization is the inability to convert economically large quantitites of lignocellulosic materials.[13]

Wood in Construction

With the exception of fuel, more wood is used for construction than for any other single application. In 1976, construction accounted for about 60 percent of the lumber and two-thirds of the plywood consumed in the United States. Major demand comes from the homebuilding industry, followed by residential upkeep and repair, and nonresidential construction (table 13).

The relationship between new construction and demand for wood has both positive and negative implications for the solid wood products sector. The industry has benefited from the increase in the number and size of new single family homes which has occurred since World War II, because they use more wood than multiunit or manufactured housing. However, residential construction is highly cyclical, with more pronounced highs and lows in economic activity than most other industries. As a result, the solid wood products sector sometimes is strained to meet demand during peak building years, such as the peak between 1972 and 1976 when housing starts exceeded 2 million annually. On the other hand, it sometimes is severely depressed, as has been the case since 1981 when housing starts fell to about 1 million per year.[*]

The amount of wood used in each housing unit varies according to construction materials and methods, the structure's type and size, architectural design, building codes, and region. Major changes in residential building materials have occurred since 1950, including greater use of plastics, metals, and masonry as substitutes for wood. Modern construction techniques, including use of prefabricated roof trusses and floor joist systems and factory prepared doors, windows, and cabinets, also tend to reduce the amount of wood used per unit of floor space.

Wood nonetheless remains the dominant material for homebuilding. Although wood use per square foot has declined, the overall size of single family houses has increased rapidly in

Photo credit: U.S. Forest Service

New home construction is the most important single use of solid wood products

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[13] U.S. Department of Energy, *Report of the Alcohol Fuels Policy Review* (Washington, D.C.: U.S. Government Printing Office, 1979).

[*] The 1970-82 period saw both the high and low points in new home construction in the post World War II period. In 5 years during the 1970's, housing starts exceeded 2 million per year (1971, 1972, 1973, 1977, and 1978). Post-World War II low points were in 1975 (1.2 million starts), 1981 (1.1 million), and 1982 (1.1 million).

Table 13.—Domestic Consumption of Lumber and Panel Products, 1976

End use	Lumber			Plywood			Other panel products				
	Million board feet	Tons (million)	Percent of total lumber	Million square feet (3/8" basis)	Tons (million)	Percent of total plywood	Million square feet (3/8" basis)	Tons (million)	Percent of total panels	Total tons (million)	Percent of total wood
Construction	25,246	26.8	59.4	13,585	7.6	66.2	6,795	4.5	50.3	38.9	59.4
New residential	16,555	17.6	39.0	8,410	4.7	41.0	3,540	2.3	26.2	24.6	37.6
New nonresidential	3,001	3.2	7.1	1,825	1.0	8.9	2,160	1.4	16.0	5.6	8.6
Upkeep, repair, and maintenance	5,690	6.0	13.3	3,350	1.9	16.3	1,095	0.7	8.1	8.6	13.1
Railroad and other ties	1,220	1.3	2.9							1.3	
Manufacturing	4,300	4.6	10.2	1,550	0.9	7.5	3,480	2.3	25.7	7.8	11.9
Household furniture	2,540	2.7	5.9	700	0.4	3.4					
Commercial furniture	260	0.3	0.7	220	0.1	1.0					
Other	1,500	1.6	3.5	630	0.4	3.1					
Shipping	6,900	7.3	16.2	738	0.4	3.6				7.7	11.7
Containers	1,140	1.2	2.7	318	0.2	1.6					
Pallets	4,900	5.2	11.5	400	0.2	2.0					
Dunnage, blocking, and bracing	860	0.9	2.0	20	<0.1	<0.1					
Other	4,785	5.1	11.3	4,638	2.6	22.6	3,248[a]	2.1	24.0	9.8	15.0
Total	42,451	45.1	100.0	20,511	11.5	100.0	13,523	8.9	100.0	65.5	100.0

[a] Includes shipping.

SOURCE: Adapted from *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: Department of Agriculture, Forest Service, 1982).

the post-World War II era. As a result, the amount of wood used per unit has increased slightly over the last two decades.[14]

Floor area of the average new single family house has increased over 70 percent between 1950 and 1979.[15] The proportion of new single family homes with garages increased from 40 percent in 1950 to 76 percent in 1980, including over 60 percent with room for two or more cars.[16] The exterior walls of 42 percent of all new single-family houses were wood in 1980 as compared to 32 percent in 1959.[17] These architectural trends have been offset somewhat by other trends that reduce wood use, such as more split-level and two-story houses and fewer porch and roof overhangs.

Long-term trends in housing demand depend on several interrelated factors, including:

- demography,
- general economic conditions and per capita income,
- national housing and financial policies,
- housing affordability, and
- cultural and personal housing preferences.

Throughout the 1970's, many housing experts projected a continued upward swing in housing starts through 1990 and perhaps to 2000. The expected increase in housing demand was linked more to the "baby boom" generation reaching prime home-buying age than to economic factors and government policies that affect construction and affordability. The demographic demand for housing in the 1980's and 1990's theoretically should be high. The number of Americans in prime household formation ages (24 to 35) will peak around 1985 and will continue at near record levels until 1990 before tapering off.[18]

The length and severity of the housing downturn in the early 1980's, however, has resulted in reevaluation of these projections. Some analysts anticipate new home construction to rebound to record levels when economic conditions improve, as it did in the seven previous housing cycles after World War II. Others, more pessimistic, say that a profound change is occurring in the U.S. housing market because the cost of homeownership is rising faster than family income. Such conditions are likely to limit the construction of detached single-family homes, and residential housing needs increasingly may be met through rehabilitation of older units, conversion of existing single-family units to multiple units, more new multifamily units, and manufactured housing. These events would reduce projected wood use in new construction but also could expand markets for wood in home improvement.

Pulp and Paper Products

The United States reports the world's highest per capita consumption of paper and paperboard products at 600 pounds per person per year. U.S. production of paper and paperboard amounted to about 64 million short tons in 1981, while domestic consumption amounted to 68 million short tons.[19]

Woodpulp is the primary raw material for all but a small portion of paper products, displacing cotton and other raw materials that dominated in the past. Annual woodpulp production has increased steadily, from about 15 million short tons in 1945 to about 53 million short tons in 1981.[20] Still, the United States imports slightly more pulp than it exports, and it manufactured 53.6 million short tons of pulp into paper and paperboard products in 1981.

Pulp and paper manufacture has grown more efficient as wood prices have risen. Early pulping processes were limited in the tree species they could use as raw material, but over time the industry has developed processes that can exploit a wider variety of species. Over the past 40 years, for example, hardwood use has increased so that it now accounts for over a quarter of the pulpwood utilized. The industry also relies heavily on chips and sawmill residues that are the byproducts of solid wood product manufacture, to the extent that they comprise over 40 percent of the wood used for pulping. Fifteen million short tons of recycled wastepaper were used in domestic pulp and paper production in 1981, compared to 12 million short tons in 1970.[21]

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[14] University of Wisconsin Extension, Environmental Awareness Center, *Housing and Wood Products Assessment,* final report to the U.S. Congress, Office of Technology Assessment, Dec. 10, 1982, p. 21ff.

[15] Ibid., p. 22. It should be noted that square feet of finished floor area declined slightly in 1980.

[16] Ibid., p. 24.

[17] Ibid., p. 32.

[18] President's Commission on Housing, *Report of the President's Commission on Housing* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 67.

[19] American Paper Institute, *Statistics of Paper, Paperboard and Wood Pulp—1982,* data through 1981 (New York: American Paper Institute, 1982), table 1.

[20] 1981 figure is from Ibid., p. 52; 1945 figure is from U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030,* Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, December 1982), p. 61.

Research has expanded the number of products that can be made from paper. Several thousand different kinds of paper and paperboard (a stiff, heavy paper) can be manufactured. These range from fluffy absorbent tissues to extremely stiff board-like materials and experimental super-strength papers that match the strength and/or weight characteristics of some light structural metals.

Woodpulp use is evenly split between paper and paperboard production. The most important paper products include printing and writing papers (51 percent), newsprint (17 percent), tissues (14.5 percent), and packaging (17.7 percent) (table 14). Linerboard, a kraft paperboard used for boxes, shipping containers, and packaging, accounted for 46.4 percent of the paperboard produced in 1981. Packaging is a rapidly growing market, comprising nearly 60 percent of domestic paper and paperboard production in 1981.

Increasing domestic and worldwide demand for paper and paperboard are anticipated. The Department of Commerce, for instance, forecasts a 3 percent annual growth rate through

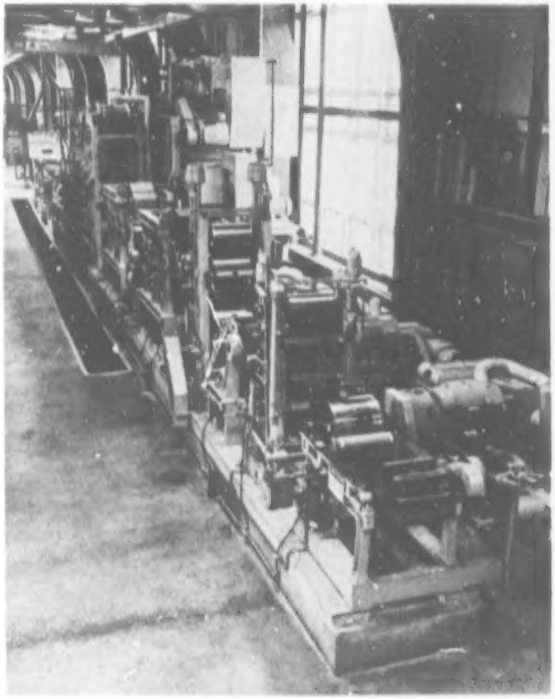

Photo credit: U.S. Forest Service

Researchers at the USDA Forest Products Laboratory are investigating new papermaking technologies

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[21] American Paper Institute, *Statistics of Paper, Paperboard and Wood Pulp—1982,* p. 50.

Table 14.—U.S. Production of Paper and Paperboard in 1981 and Projected for 1984 (thousand tons)

	1981	1984[a]
Paperboard	14,558	15,360
Kraft fiberboard	1,067	1,140
Other kraft paperboard	4,717	5,070
Bleached paperboard	3,926	4,100
Recycled paperboard	7,070	7,150
Total paperboard	31,338	33,020
Paper		
Uncoated free sheet	7,882	8,720
Coated free sheet and groundwood	4,951	5,340
Uncoated groundwood	1,440	1,540
Bristols and other	1,530	1,580
Total printing and writing	15,803	17,180
Newsprint	5,238	5,730
Unbleached kraft	3,891	3,760
Bleached regular and industrial	1,603	1,670
Tissue	4,485	4,730
Total paper	31,020	33,070
Total paperboard and paper	62,358	66,090

[a] Morgan Stanley Estimates.

SOURCE: Thomas P. Clephane and Jeanne Carroll, *Linerboard Industry Outlook* (New York: Morgan Stanley & Co., 1982), p. 25.

1986.[22] Linerboard and high-quality printing papers are expected to have especially promising potential, with anticipated growth rates that are twice that of the paper sector as a whole. Particularly high prospects for growth lie in the export markets, especially in the expanding industrial economies of Asia. Continuation of the adverse economic conditions of 1982, however, could dampen these prospects.

Some experts believe that paperboard will account for a larger share of paper sector production due to increased paperboard demand and slower growth in other paper (nonpaperboard) markets. For example, paper has lost part of the packaging market to plastics, although in some instances plastics have been combined with paper to produce composite products. Electronic communications and information processing ultimately may displace some paper now used in writing, copying, printing, and business forms. To date, however, electronic communications have provided high-volume markets for paper use in office copiers and word processing equipment.

Other Wood Products

Furniture and Other Manufactured Products

Wood is an important manufacturing material. Furniture and other products accounted for about 10 percent of lumber, veneer, and plywood and 40 percent of hardboard and particleboard used in 1976.[23] Furniture alone accounted for well over half the wood used in manufacturing, with the remainder used for a variety of small volume items, including signs, displays, sporting goods, musical instruments, boats, tools, and coffins.

After rising during the previous decade, the volume of wood used in furniture and other manufactured goods began to decline during the early 1970's due to the increased use of materials such as metals and plastics, more efficient use of wood in manufacturing, and the small number of new products made from wood. Wood use in furniture also depends on consumer preferences. During the 1960's and 1970's, plastics and metals were substituted for wood in some popular styles of furniture, but between 1972 and 1977, wood apparently regained popularity.[24]

Shipping and Industrial Uses

During the past 15 years, the production of wooden pallets to store and ship materials has expanded. This growth reflects the increased use of palletized materials handling systems and the increased volume of manufactured goods shipped. The expanded use of pallets has offset the rapid decline in wood used in shipping containers and crates, which have been rapidly replaced by plastic containers and metal barrels. Further increases in pallet production are expected by the Forest Service.[25]

Other industrial markets have declined significantly due to the substitution of other materials and the development of better wood preservatives. Railroad ties, once one of the highest volume uses for wood, accounted for only about 1.5 billion board feet of lumber in

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[22] U.S. Department of Commerce, Bureau of Industrial Economics, *1982 U.S. Industrial Outlook* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 43.

[23] *An Analysis of the Timber Situation*, op. cit., p. 33.

[24] Ibid., p. 35.

[25] Ibid., p. 37-38.

1976.[26] Nonetheless, demand for railroad ties has edged upwards since the 1960's. Future trends in railroad tie use will depend on the competitiveness of alternatives such as concrete ties and public and private commitment to maintaining, improving or expanding domestic railroads. Other uses for wood, such as telephone poles, pilings, barrel staves, and mine timbers, have declined by about one-third since 1952, to 379 million ft^3 in 1977.

Chemicals and Cellulosic Fibers From Wood

Wood is the primary raw material from which highly refined cellulose is taken to make rayon and cellulose acetate filaments. Rayon and acetate are found in many products, including automobile tires, lacquers, and explosives.

The volume of cellulosic fiber production peaked in 1969,[27] and shipments in 1981 were valued at $1.5 billion.[28] Although the market is now dominated by noncellulosic fibers such as polyester, some analysts believe that wood-based rayon and acetate will become more competitive with noncellulosic fibers produced from petrochemicals if energy costs increase. Cotton is another major competitor with rayon, but the degree to which rayon can displace it will depend on worldwide demand and the supply of cotton. The success of rayon and acetate will depend, too, on improvements made in these fabrics.

The forest products industry also produces silvichemicals valued at over $500 million per year (table 15). Primary silvichemicals include naval stores (e.g., rosin, pine oils, and turpentine) and a variety of byproducts from pulping, including lignin products and vanillin.[29]

Technologies exist for wood to replace virtually all of the chemicals and plastics made from petrochemicals, although the most likely near-term substitute for petroleum is coal. Some researchers consider wood's potential to be great for providing unique chemicals not now available. Lignin, now primarily burned for energy during the pulping process, may be especially promising. While lignin can be used to make a variety of organic chemicals, it is difficult to process and less than 3 percent remaining after pulping is recoverable for chemical production. Additional research on lignin's complex molecular structure, which is not well understood, is needed before the potential of lignin can be realized. Advances in biotechnology also may increase chemical production from wood.[30]

Nutritional Products

Wood fermented by yeast can produce several high protein products to feed livestock and to supplement human diets. These nutritional products include:

- roughage used in animal and some human foods;
- wood molasses, a sugar substitute;
- single-cell protein for animal and human nutrition; and
- flavorings, such as vanillin.

The value of wood-based feed and food products in 1977 was about $40 million. Vanillin, which is used as a substitute for vanilla beans in ice cream and other products, accounted for three-fourths of this total.[31]

Advanced Wood Materials

Research by the U.S. Forest Products Laboratory has shown the feasibility of producing paper that is stronger than the wood from which it is made. In fact, this "superpaper" substantially exceeds the specific strength- and stiffness-to-weight ratios of all common structural materials. If such high-strength papers also can be made moisture resistant, maintaining their stiffness and dimensional stability, they could be used for a wide range of applications now served by solid wood, plastics, and

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[26] Ibid., p. 30.

[27] Ibid., p. 57.

[28] *1982 U.S. Industrial Outlook*, op. cit., p. 314.

[29] *An Analysis of the Timber Situation*, op. cit., p. 64-67.

[30] See Henry R. Bungay, "Biomass Refining," *Science*, Nov 12, 1982, pp. 643-646, for a discussion of recent developme [illegible]

[31] *An Analysis of the Timber Situation*, op. cit., table [illegible]

Table 15.—Production and Value of Silvichemicals in the United States in 1977

Product	Unit	Production (millions of units)	Average price[a] ($/unit)	Annual value (millions of dollars)	Average annual growth in production (1963-77) (percent)
Naval stores[b]					
Gum rosin	lb	26	0.27	$7.0	-15%
Steam-distilled rosin	lb	246	0.23	56.6	-6
Gum turpentine	gal	0.73	1.50	1.0	-15
Steam-distilled turpentine	gal	2.54	1.25	3.2	-8
Pine oil	gal	9.49	2.00	19.0	0
Other terpenes	gal	2.32	1.00	2.1	
Subtotal				$89.2	
Sulfate mill products					
Crude tall oil	lb	1,518	0.09	(c)	+3.1
Crude tall oil, used as such or sold	lb	214	0.09	19.3	
Distilled tall oil[d]	lb	103	0.19	19.6	+1.6
Tall oil rosin	lb	406	0.20	81.2	+2.8
Tall oil fatty acids	lb	359	0.27	96.9	+3.0
Sulfate turpentine (refined)	gal	20.61	1.10	22.7	+0.7
Heads fraction, pitch	lb	300[e]	0.05[e]	15.0[e]	
Sulfate lignin	lb	60[e]	0.05[e]	3.0[e]	
Dimethylsulfide	lb	8[e]	0.37	3.0	
Dimethylsulfoxide	lb	1[e]	0.54	0.5[e]	
Subtotal				$261.2	
Sulfite mill products					
Lignosulfonate, Ca-base	lb	534	0.05	26.7	
Lignosulfonate, Na-base	lb	109	0.06	6.5	
Lignosulfonate, other[f]	lb	516	0.04	20.6	
Lignosulfonate, total[f]	lb	1,160	0.06	(c)	+7.6
Ethyl alcohol, 190-proof	gal	5	1.00	5.0	+2.6
Vanillin	lb	5.6	5.35	30.0	+10.4
Torula food yeast, dry	lb	16	0.40	6.4	+5.1
Acetic acid, glacial[g]	lb	8	0.20	1.6	0
Subtotal				$96.8	
Miscellaneous products					
Arabinogalactan		NA	NA	NA	
Charcoal briquettes	lb	1,100	0.06	66.0	+1.5
Active carbon, from wood	lb	50[e]	0.25	12.5[e]	
Hemicellulose extract	gal	2	0.09	0.2	
Wax, from bark	lb	1.2	0.22	0.3	
Extracted bark powder	lb	35	0.06	2.1	
Subtotal				$81.1	
Grand totoal				$528.3	

NA = Not applicable.

[a] Carload or wholesale price, f.o.b. mill.

[b] Naval stores data pertain to crop year, April 1 to March 31.

[c] Value accounted for under other headings.

[d] Includuing acid-refined tall oil.

[e] Including lignosulfonates made from sulfate lignin.

[f] Estimated.

[g] Made from NSSC spent pulping liquors.

SOURCE: Lars C. Bratt, "Wood Derived Chemicals: Trends in Production in the U.S.," *Pulp and Paper*, June 1979.

metals. When coupled with design innovations for paper-based structural materials, they eventually may play a role in residential construction. However, considerably more research and development are needed before super strength paper can be marketed.

Solid wood products have been designed to compete directly with structural steel and concrete in some uses. Large laminated beams and arches, frequently bent into various shapes, have entered new markets, including the construction of large indoor sports arenas, convention centers, churches, and domes.

In addition, all-weather wood foundations and underfloor plenum systems can compete with masonry, block or cast-in-place concrete in new homes. The all-weather wood foundation is made of preservative-treated plywood and lumber placed partially below ground level. The underfloor plenum system provides a sub-floor area through which warm or cool air can be distributed throughout the house for heating or air-conditioning, thus eliminating ductwork. Properly constructed, the plenum is rot- and insect-resistant.[32] Widespread use of either system would significantly increase wood use in home construction; e.g., the underfloor plenum system requires 20 percent more wood compared to slab built houses.[33]

Though wood foundations are cost competitive with conventional foundations, they are not yet widely accepted. Reasons for this may be related to a conservative building construction industry, buyer reservation, and the reluctance of building tradespeople to adopt new technologies.

Many new wood products displace more traditional wood products such as plywood or lumber rather than competing with other materials. These products may help maintain traditional wood markets but do not usually open new ones. Often the net effect is to reduce the volume of wood used. Prefabricated roof trusses, for example, have not expanded wood markets significantly but have replaced larger dimension lumber in light frame construction.

Medium-density fiberboard, first produced in the mid-1970's, has rapidly expanded into furniture markets formerly held by particleboard and other panels. New types of particleboard include panels made from strands (thin shavings or slivers of wood), flakes or wafers, sometimes with veneer faces. These panels, first introduced in the United States and Canada in the mid-1970's, compete with softwood plywood in structural uses.

New panel products made from reconstituted wood are expected to replace plywood for sheathing and underlayment (floors). The same trend seems to have occurred in furniture manufacturing where plywood and particleboard have replaced lumber as furniture corestock, and medium-density fiberboard, in turn, has replaced much of the plywood and particleboard. Shipping pallets are replacing wood boxes and containers for materials handling. New types of pallets, made with plywood decking, particleboard, or medium-density fiberboard, may replace some hardwood pallets in the future.

Composites that combine wood with other materials are not common, but their use is growing. Composites made by laminating plastic or metal skins to a wood core are currently used in a number of industrial applications calling for strong, durable, corrosion-resistant materials. Cement board made from wood and cement and insulation made from wood and foam are two other applications of composites. Advanced materials, such as dimension lumber substitutes made from wood particles and high tensile strength glass fibers, could further broaden the range of wood composites.

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[32] National Association of Homebuilders Research Foundation, *Plen-Wood System: A Design/Construction Manual* (Rockville, Md.: National Association of Homebuilders Research Foundation).

[33] National Association of Homebuilders Research Foundation, personal communication with W. Davidson, contractor, OTA, January 1983.

Projected U.S. Consumption of Timber and Wood Products

For nearly a century, the Forest Service periodically has analyzed the U.S. timber situation. The Forest and Rangeland Renewable Resources Planning Act of 1974 directs the Secretary of Agriculture to prepare an assessment of renewable resources every 10 years. Under the National Forest Management Act of 1976 (Public Law 94-585), the Forest Service also prepares a national renewable resource program updated at 5-year intervals. The latest assessment, issued in 1980, presents projections of timber demand, supply, and prices through 2030.

From each assessment, alternative programs for the use and management of the Nation's renewable resources are prepared, and these in turn form the basis for formulating Federal budgets. The 1980 assessment forecasts increasing timber scarcity coupled with rising prices and demand for timber products during the next 50 years. This scarcity, according to the Forest Service, will have "significant adverse effects on primary timber processing industries, timber inventories, consumers of wood products, and the environment."[34]

The 1980 projections probably overstate the future scarcity of timber, primarily because of overestimated demand.[35] The forecasts that appear in the 1980 assessment were prepared in the late 1970's, and many significant changes in the Nation's economic outlook have occurred since then that alter expectations about timber demand and other assumptions used in the model. Recognizing these changes, the Forest Service currently is modifying both the 1980 forecasts and the forecasting process to include updated assumptions about future conditions and to provide a range of future outcomes.

While it is useful for planning purposes to project future timber demand and supply, it is important to recognize the shortcomings of mathematical modeling when it is applied to public administration and public policy. The complexity and sophistication of the econometric models used in forecasting often give the illusion of certainty and accuracy, while in fact the most complex models may provide information that is no more reliable than off-the-cuff estimates or professional intuition. The primary value of modeling may be less in predicting future conditions than in evaluating the relationships between certain economic conditions and the timber situation. The usefulness of the Forest Service's projections for policymaking will be greatly enhanced by considering a range of assumed conditions in developing estimates of future timber situations, rather than merely providing specific estimates of timber demand and supply based on a single or narrow set of assumptions.

The next assessment by the Forest Service probably will describe a broader range of possible futures. The 1980 assessment reflects little recognition and analysis of factors that affect timber consumption and presents only a single most-likely-case scenario—that timber will become more scarce, based on demand rising faster than supply. While this projection is within the range of **possible** futures, there are two reasons to doubt that it is the most likely outcome: 1) estimates of future economic growth and demand for timber products are too optimistic and are much more likely to be overestimated than underestimated, and 2) while the long-term national timber supply may be understated, projections of supplies of softwoods from certain regions may be overestimated.

Demand Projections

Projections of demand for wood cover a wide range of products, including lumber, panels, fuel, pulp, and paper. Future consumption for all products is linked to the level of general economic activity, and demand for many goods is estimated by indexing product use to the GNP. Demand for wood products used in housing is forecast separately.

Housing Demand

The Forest Service's 1980 assessment forecasts rapidly rising consumption of lumber and plywood as a result of projected high levels of new home construction like those of the early and mid-1970's. Since these projections were made, however, there have been significant changes in the housing market that may have a long-term impact on the strength of future demand, home size and type, and consequently the amount of wood products used in construction. These changes and several others, all point to future consumption of wood products below the levels forecasted in the 1980 assessment. A downward revision of Forest Service projections therefore is justified because:

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[34] *An Analysis of the Timber Situation*, op. cit., p. xxiii.

[35] Personal communication from Bruce R. Lippke, Weyerhaeuser Co., to R. Max Peterson, Chief, Forest Service, Mar. 17, 1983.

- In the Forest Service model, a substantial portion of future new construction is "replacement" housing, i.e., those units built when existing houses are abandoned or razed. However, the model assumes replacement rates will be sustained at levels much higher than in the past, except during the 1960's when a larger proportion of wartime housing was replaced. Unless repair and remodeling decrease dramatically, it is likely that future replacement rates will be much lower than forecasts indicate. Since housing unit replacements account for nearly half of all future homebuilding used in Forest Service forecasts, adjustment of the replacement rate will substantially effect the projected pace of construction.
- Housing affordability affects housing demand, unit type, and home size, but it is not adequately reflected in Forest Service projections. Home prices increased rapidly relative to household income in the 1970's, partially as a result of inflation and low real interest rates, conditions not likely to be duplicated in at least the next decade or two.
- Reduced housing affordability and household size both point to decreasing home size in the future. However, whether or not average unit size will reach 2,000 ft² by 2030, as the Forest Service estimates, is uncertain; it is not unlikely that home size could stabilize or even decrease within 50 years.
- Household size, lifestyle, and consumer preference also could significantly effect the type of housing built. The Forest Service forecasts multifamily and mobile home units declining as a proportion of construction in the future and single-family detached units accounting for a growing share. It is probably equally likely that multifamily units and mobile homes will account for a stable or increasing share of future construction. Single-family homes use more wood products than either multifamily units or mobile homes per unit of floor space.

These are among the many reasons to doubt that the strong homebuilding activity of the past will recur, yet they are not adequately recognized in 1980 Forest Service forecasts. For the last 4 years, the homebuilding industry has been depressed. The extent to which current conditions will continue or how the industry will respond to recovery is unknown. It is possible that a full recovery could lead to more housing construction in the future, particularly since housing demand by the baby boom generation is expected to be strongest in the 1980's. This is based primarily on demographics, however, which is only one of a number of things that affect housing demand.

Demand for Timber in Other Uses

Demand for wood products other than for new housing is, in general, tied to the level of economic activity and population expected in the next 50 years. Forest Service estimates of future GNP and disposable personal income are based on projections made by the Department of Commerce's Bureau of Economic Analysis (BEA). The BEA projections show future annual GNP growth of 2.0 to 3.7 percent, leading to a quadrupling of GNP by 2030 and thus to a substantial increase in demand for wood.

While these GNP forecasts are not inconsistent with past trends, some private sector timber demand forecasts use slightly lower estimates.[36] The 1980 asessment, however, gives little consideration to the effects of different assumed levels of economic growth on wood demand, except to note that consumption of lumber and plywood are insensitive to changes in GNP growth in the short run.[37] There is a great deal of uncertainty in any forecast of economic activity for as long a period as 50 years, and even small changes may have considerable impact on future wood needs. This impact is not adequately recognized in the 1980 assessment.

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[36] Discussion of timber consumption forecasting models and assumptions used in various models can be found in Perry R. Hagenstein, and William E. Bruner, *Timber and Wood Products Supply and Demand Analysis,* contract report to the U.S. Congress, Office of Technology Assessment, July 2, 1982.

[37] *An Analysis of the Timber Situation,* op. cit., p. xx.

Supply Projections

Actual future timber supply probably will be much different than projected in the 1980 assessment, but the magnitude and direction of the difference are not clear. Timber supply forecasting is complicated by the fact that the Forest Survey, conducted under Forest Service auspices, which provides information on forest acreage, timber stocking, and growth, is done at 10 to 15 year intervals and is not completed simultaneously in all States (see ch. VI for detailed discussion). At any given time, therefore, forecasters may be using inventory and growth data ranging in age from 1 to 15 years, and, as recent surveys have shown, outdated information can be inaccurate. New surveys completed since the 1980 assessment show that the softwood supply in the Pacific Northwest, present and future, definitely was underestimated, but that the future softwood supply in the South, particularly on nonindustrial private forestland, may be significantly overstated.

Overall, the Forest Service's supply projection process probably produces very conservative estimates of nationwide future timber growth for three reasons:

- Forest Service projections are based on short-term supply curves. These show that even large increases in stumpage prices produce only very modest increases in timber harvest. This relationship seems reasonable in the short run, since it takes 30 or more years to grow mature timber. However, in the longer run, covering the 50-year projection period used in the 1980 assessment, timber supply is probably much more responsive to stumpage prices than short-run analysis indicates. With rising stumpage prices, a much broader range of investments in timber management to increase future supply is feasible.
- The 1980 assessment projections assume no increase in management intensity over 1970's levels, which may be unreasonable because higher stumpage prices probably would prompt many landowners to invest more heavily in timber management.
- The Forest Service forecasts rely on extremely conservative conversion rates to translate wood products consumption into demand for raw timber. The amount of timber required for wood products is affected by manufacturing technology and forest utilization, and there are many currently available technologies that can reduce the amount of roundwood needed to make a wide variety of goods. In addition, technological advances have made it possible for woody biomass, previously considered waste, to be used in product manufacture. Rising stumpage prices are likely to stimulate investment in more efficient manufacturing equipment as well as an increase in use of forest biomass, both of which tend to increase the supply of usable wood. The effects of increased forest utilization and more efficient manufacturing technology probably are understated in the 1980 assessment.

Timber Consumption Projections

According to the 1980 assessment, timber consumption from domestic forests is projected to rise from over 12 billion ft^3 in 1976 to approximately 23 billion ft^3 in 2030 (fig. 11). The greatest rate of projected increase takes place between 1980 and 1990, due mainly to the strong housing demand of the baby boom generation, now entering the 28- to 35-year-old age group of primary homebuyers.*

Most of the increase in timber consumption between 1952 and 1976 was supplied by softwoods, whose use rose from 7.2 billion ft^3 to nearly 9.5 billion ft^3. Hardwood use, in con-

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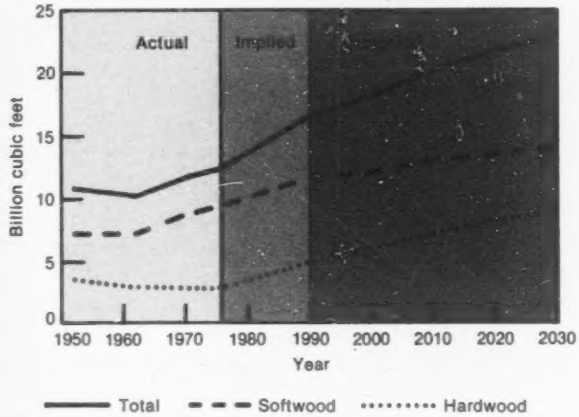
*Forest Service forecasts do not attempt to forecast short-term consumption between 1976 and 1990. The forecasts begin with 1990 consumption. However, attaining these levels by 1990 requires a substantial increase in short-term consumption.

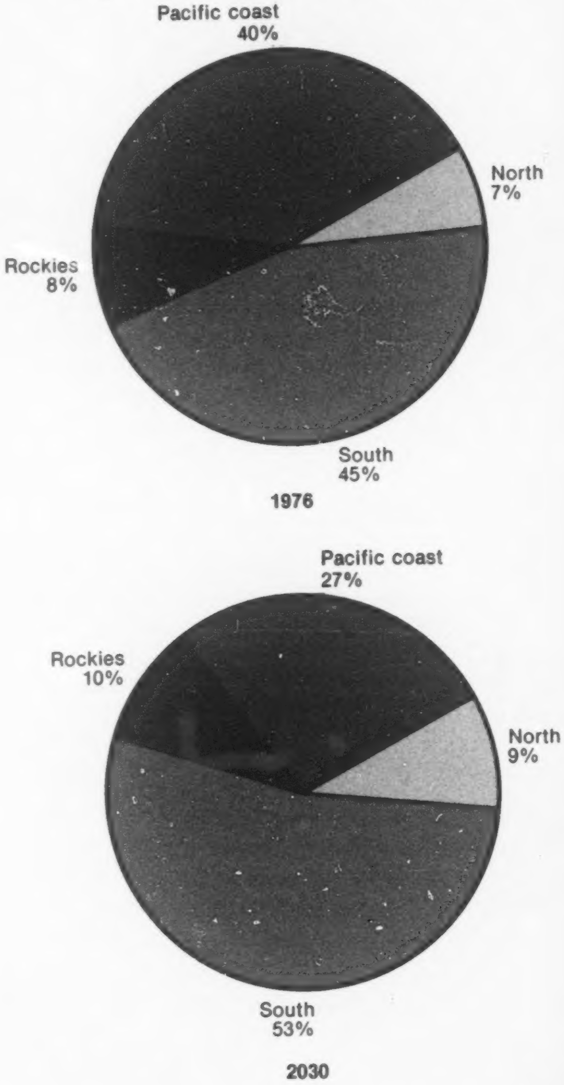
Figure 11.—Domestic Timber Consumption, 1952-2030



SOURCE: Adapted from the U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), p. 202-215.

trast, remained relatively stable at about 3 billion to 3.5 billion ft³. By 2030, a large portion of the increased timber consumption from domestic forests is projected to be in hardwoods, primarily for paper, pallets, and hardwood veneer for furniture. Hardwood use is projected to rise to nearly 9.0 billion ft³, up from nearly 2.9 billion ft³ in 1976—a jump of over 300 percent. Softwood consumption is expected to rise by 50 percent, to 14.0 billion ft³.

Figure 12.—Softwood Timber Production: Regional Distribution, 1976 and 2030



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), p. 202-215.

Regional Timber Production

Forecasted regional distribution of timber production through 2030 indicates that softwood operations will continue to shift to the South (fig. 12). This shift projected in the 1980 assessment reflects a decline in production in the Pacific Northwest, thought to be caused by a drop in timber inventories due to overcutting on forest industry land.* Since the 1976 projection was made, however, a resurvey in the Pacific Northwest shows that timber growth on forest industry land is significantly higher than had been previously estimated, and it is likely that new Forest Service projections now in preparation will reveal a much smaller decline in Pacific Northwest harvests. In addition, recent information shows that projected southern softwood supplies are probably too high. Forecasts are being revised to reflect these changes.

In 1976, the South produced 51 percent of the hardwood harvest, with the North producing 46 percent. Only 3 percent came from the Pacific coast. The 1980 assessment shows slight shifts in hardwood production by 2030, with the South's share increasing to 59 percent, the North declining to 39 percent, and the Pacific coast dropping to 2 percent (fig. 13).

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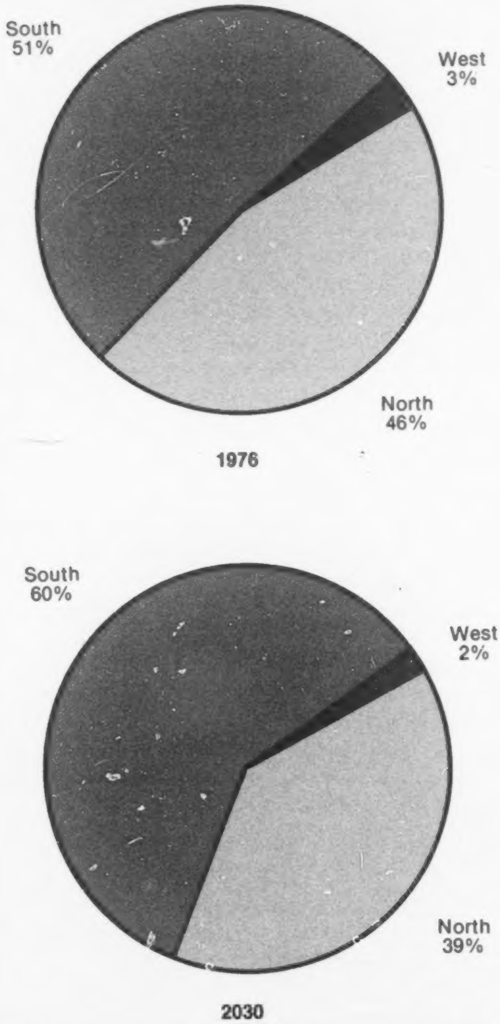
*"Overcutting" means harvesting more than net growth per unit of time, or cutting above the level of sustainable yield.

Figure 13.—Hardwood Timber Production: Regional Distribution, 1976 and 2030



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), p. 202-215.

A decline in the share of production does not necessarily mean a decline in actual or volume production. In the Pacific Northwest, where the share of softwood harvest is projected to drop from 31 to 21 percent of the national total, volume production is projected to increase by 70 million ft³. In the South, where projections indicate an increase from 45 to 53 percent of the national softwood harvest, the increase in volume production is nearly 3.3 billion ft³.

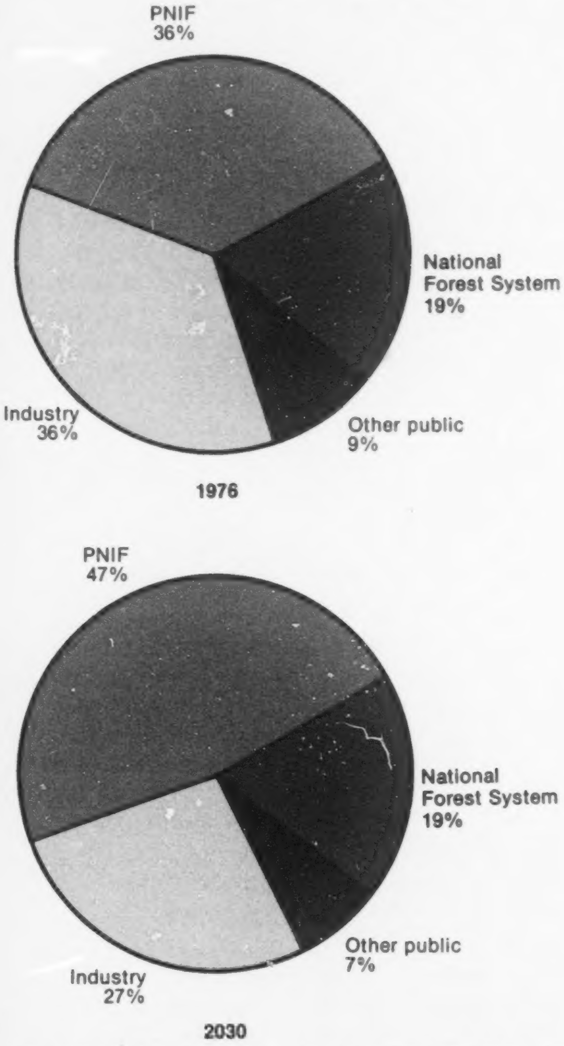
The hardwood situation is similar. The South's hardwood production is expected to more than triple, increasing from 1.7 billion to 5.4 billion ft³. The North is projected to increase its volume production from 1.5 billion to 3.6 billion ft³. In the West, hardwood harvest levels projected to increase by 37 million ft³ by 2030.

Harvest by Ownership

Projections of the timber harvest by ownership also show major shifts in the contributions of various forest land owners. In 1976, the private sector accounted for nearly three-fourths of the softwood roundwood supplies. Private industrial and nonindustrial ownerships each produced about 36 percent of the total softwood harvest (fig. 14). The public sector accounted for the remainder, with the National Forest System producing nearly 19 percent of the Nation's softwood harvest.

By 2030, the public sector is expected to contribute a slightly smaller share, while in the private sector, the forest industry's share drops to 27 percent and the nonindustrial landowners' share goes up to 47 percent. For the private nonindustrial group, this change means increasing production by 94 percent over 1976 levels, or by about 3.2 billion ft³. Despite share decreases, the harvest from forest industry lands is projected to increase slightly, by about 354 million ft³. Similarly, national forest production is projected to increase by 928 million ft³, or by about 52 percent over 1976 levels.

Figure 14.—Softwood Timber Production: Distribution by Ownership, 1976 and 2030



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), pp. 202-215.

No major changes in regional distribution of hardwood harvests are projected, although all ownerships are expected to harvest more hardwoods to meet increasing forest products industry needs. The projected increase is greatest from private nonindustrial lands, which are projected to expand hardwood harvests by 180 percent, from 2.5 billion ft^3 to approximately 7 billion ft^3.

The Forest Products Industry

The term "forest products industry" refers to the combination of the pulp and paper products and the solid wood (lumber and panel) products sectors (fig. 15). This industry contributes 1.7 percent of the total gross domestic product (GDP) and employs about the same percentage of the Nation's full-time work force.[38] The pulp and paper sector is the fourth

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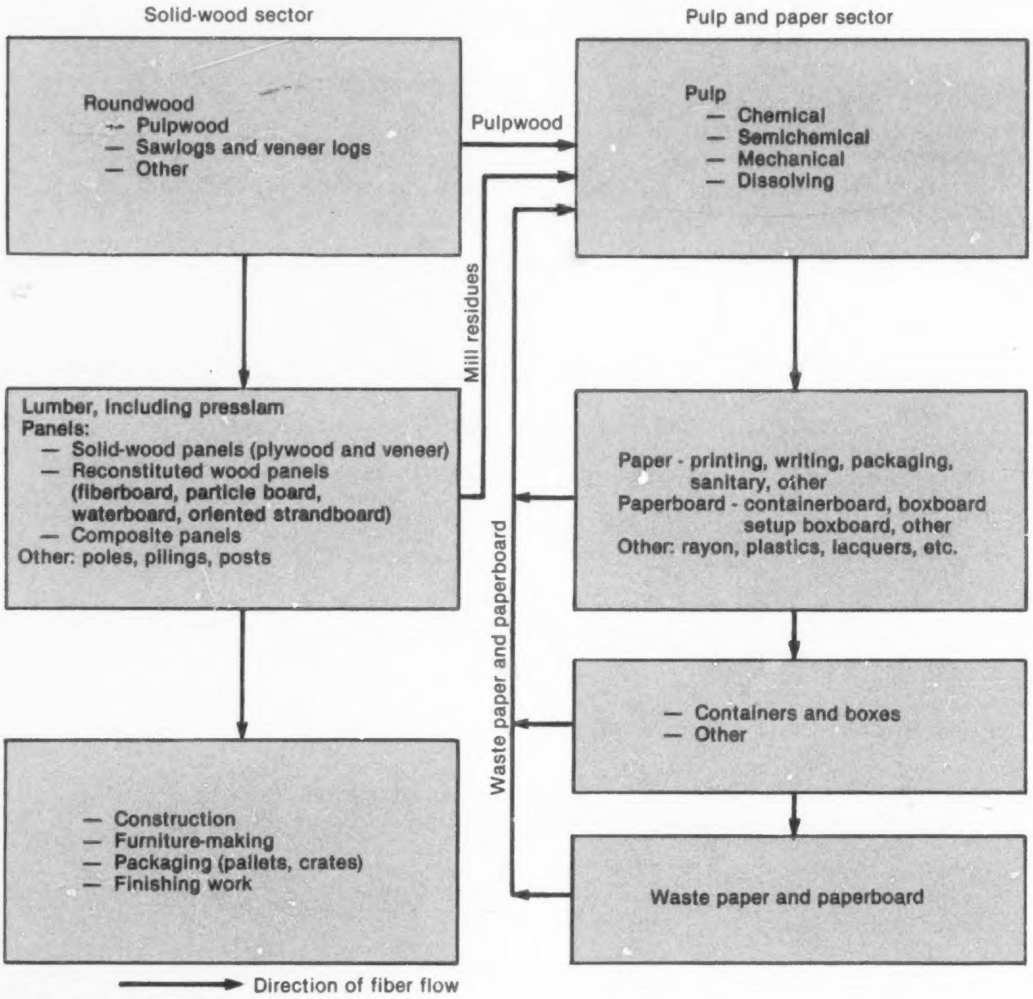
[38] U.S. Department of Commerce, Bureau of Industrial Economics, *1981 U.S. Industrial Outlook for 200 Industries With Projections for 1985* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 425.

Figure 15.—Schematic of the Forest Products Industry


Solid-wood sector
Pulp and paper sector
Roundwood
— Pulpwood
— Sawlogs and veneer logs
— Other
Pulpwood
Pulp
— Chemical
— Semichemical
— Mechanical
— Dissolving
Mill residues
Lumber, including presslam
Panels:
— Solid-wood panels (plywood and veneer)
— Reconstituted wood panels (fiberboard, particle board, waterboard, oriented strandboard)
— Composite panels
Other: poles, pilings, posts
Paper - printing, writing, packaging, sanitary, other
Paperboard - containerboard, boxboard setup boxboard, other
Other: rayon, plastics, lacquers, etc.
Waste paper and paperboard
— Containers and boxes
— Other
— Construction
— Furniture-making
— Packaging (pallets, crates)
— Finishing work
Waste paper and paperboard
Direction of fiber flow

SOURCE: Office of Technology Assessment.

largest producer of nondurable goods, and the lumber and panel products sector is the eighth largest producer of durable goods in terms of value of GDP.

The characteristics and performance of the two sectors are quite different. These differences are less, however, in the case of the larger diversified companies that manufacture both solid wood products and pulp and paper. Such firms often own significant amounts of forestland and are major employers in many areas.

Contribution to the Domestic Economy

In 1977, the forest products industry employed about 1.4 million people and contributed over $40 billion in value added. The lumber and panel products sector employs more people than the pulp and paper sector, but the pulp and paper sector ranks higher in value added by manufacturing, which reflects the prevalence of automation in papermills. Lumber and panel products is a significant consumer of adhesives and resins, preservatives, and fire retardants. Pulp and paper is a major user of industrial energy, water, and chemicals.

Primary Processing

Primary processors handle the raw wood material. In 1977, they contributed about 43 percent of the total forest products value added and employed 37 percent of the labor force of the forest products industry (table 16). The largest single employers are sawmills and planing mills, which retain 211,300 workers, followed by papermills which employ 127,000 people. Papermills lead primary operations in value added and value of shipments, followed by sawmills and planing mills.

Secondary Processing

Secondary processors in both industry sectors together employ 63 percent of the forest products labor force and contribute 57 percent of total value added. Similar to the primary processors, secondary lumber processors employ more people than do the secondary pulp and paper processors, but the latter contributes a higher value added. When measured by all

Table 16.—Number of Employees, Value Added, and Value of Shipments for Primary and Secondary Forest Products Industry in 1977

Industry	Number of employees (thousands)	Value added by manufacture (million dollars)	Value of shipments (million dollars)
Primary lumber:			
Logging camps and contractors	83.3	2,418.7	6,230.1
Sawmills and planing mills	211.3	4,974.8	11,969.3
Total	294.6	7,393.5	
Percent of grand total	20.9	18.4	
Primary paper:			
Pulpmills	16.2	906.1	2,091.1
Papermills (except building paper)	127.0	5,406.6	12,613.3
Paperboard, building paper and board mills	74.6	3,298.9	7,598.0
Total	217.8	9,611.6	
Percent of grand total	15.4	23.9	
Gum and wood chemicals:			
Percent of grand total	0.3	0.4	
Primary total:			
Percent of grand total	36.7	42.8	
Secondary lumber:			
Millwork, plywood, and structural members	183.3	4,370.8	10,596.0
Wood containers, and miscellaneous wood products	50.4	866.8	2,179.7
Wood buildings and mobile homes	79.5	1,789.1	5,147.9
Furniture and fixtures	196.9	3,388.1	6,162.9
Total	510.1	10,414.8	
Percent of grand total	36.2	25.9	
Secondary paper:			
Paperboard containers and boxes	176.1	5,296.2	13,350.1
Sanitary paper products	34.5	2,194.5	4,921.2
Bags	48.7	1,349.6	3,482.3
Other converted paper and paperboard products	123.5	3,718.9	8,029.7
Total	382.8	12,559.2	
Percent of grand total	27.1	31.3	
Secondary total:			
Percent of grand total	63.3	57.2	
Grand total	1,410.1	40,164.1	

SOURCE: *1977 Census of Manufacturers, Parts 1 and 2* (Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, 1981).

parameters displayed in table 16, the two largest secondary lumber subgroups are millwork, plywood, structural members, and furniture and fixtures. The two largest paper subgroups are paperboard containers and boxes and the catch-all "other converted paper and paperboard products." Overall, paperboard containers and boxes contribute the largest value added of the secondary processors, while furniture and fixtures employs the most people.

Consumption of Industrial Commodities

The forest products industry is a major consumer of several industrial commodities. Plywood and other panels, for instance, require significant quantities of adhesives and resins, making plywood manufacture the largest single adhesives market.[39] Other solid wood products use significant amounts of phenol and urea formaldehyde resins, fire retardants, and preservatives, most of which are petroleum-based.

The pulp and paper sector is the sixth largest consumer of chemicals in terms of dollar value purchased. It also uses (but does not consume) more water for processing than any other manufacturing industry and is a leading industrial energy consumer. The pulp and paper sector uses about 7 percent of the Nation's industrial energy and 3 percent of all energy consumed in the United States. Because energy is a significant cost in producing paper, pulp and paper companies have become industrial leaders in energy conservation and cogeneration.

Structure and Performance

The financial performance of the forest products industry is neither better nor worse than that of other industries considered together. In 1980, the wood-based companies among the Fortune 500 trailed other industries in terms of total return to investors, return on stockholders' equity, return on sales, and changes in profits and sales, but 1980 is probably not a fair comparison because of the severe depression in the forest products industry. Overall, the pulp and paper sector generally performs as well as the rest of the economy, while solid wood products are subject to wide variations due to their close ties to residential construction.

The performance of any industry—its growth rate, financial performance, ability to innovate, and record in entering new markets and controlling old ones—is related to its structure. Several key structural features appear to affect the performance of the forest products industry, including the degree of competition within in the industry, landownership, product mix, diversification, and sensitivity to economic changes.

Degree of Competition

Industrial structure is commonly thought of in terms of the degree of competition within the industry. An industry is described as "competitive" at one extreme if no firm holds a significant proportion of market power and "monopolistic" at the other extreme if one firm controls the whole industry. While there are probably no industries at either extreme, the forest products industry is generally considered fairly competitive. In 1978, the top four forest products firms accounted for almost 15 percent of all wood-based sales, and the top nine accounted for 22 percent of industry sales.[40]

The lumber and panel products sector is commonly described as one of the Nation's most competitive, with over 30,000 companies, while the pulp and paper products sector, with almost 4,000 companies, is less fragmented.

In reality, however, the picture is more complicated than the number of companies alone would indicate. The lumber industry, the most competitive component of the lumber and panel products sector, counts over 8,000 establishments, 80 percent of which employ fewer than 21 people. However, 50 percent of the total domestic lumber output is produced by 10 percent of the mills.[41]

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[39] Peter Gwynne, "Adhesives: Bound for Boundless Growth," *Technology*, January/February 1982.

[40] Jay O'Laughlin, and Paul V. Ellefson, "U.S. Wood-Based Industry Structure: Part 1—Top 40 Companies," *Forest Products Journal*, October 1981, p. 56.

There are fewer mills in the panel products industry—232 softwood veneer and plywood mills, 366 hardwood plywood and veneer mills, and 68 particleboard mills, employing about 77,000 people. Whether or not the panel products industry as a whole is more or less competitive than the lumber industry is unknown.

The pulp and paper sector is less competitive than any major part of the lumber and panel products sector. There are over 4,000 pulp and paper establishments, but the 10 largest firms account for over half the pulp, paper, and paperboard products manufactured in the United States.[42]

Forest Land Ownership

The fastest growing companies in the forest products industry often own substantial timber acreage.[43] In 1977, the industry owned about 14 percent of all commercial forestland or 69 million acres.[44] The top 40 firms accounted for 80 percent of this acreage. The same firms accounted for 40 percent of all domestic wood-based sales in 1978.[45]

Wood is a major portion of the production cost of lumber, plywood, and paper. Timber is estimated to account for 72 percent of the cost of manufacturing lumber, 46 percent of the cost of making plywood, 30 percent of the cost of making linerboard, and 18 percent of the cost of manufacturing white papers.[46] Timber costs have stimulated the many dominant forest products firms to maintain fee simple ownership of land, usually near company mills.[47] Fee simple ownership gives a company a strong bargaining position with neighboring private nonindustrial timber owners as well as a source of less expensive timber when stumpage prices increase. This may serve as a "yardstick" for establishing the local price of timber.

While forest land ownership may be a wise business strategy for forest products firms, it can cause local problems. In some southern communities, timber industry land "banking" may affect the availability of land for community development, housing, and other purposes.[48]

Access to high-quality timber has figured prominently in the performance of the forest products industry. Since colonial times, industry concentration has shifted from the Northeast, through the Great Lakes States and the South, across the Rockies, and to the west coast to harvest available mature, high-quality timber and is continuing to shift back to the South to take advantage of low-cost, fast-growing softwood stumpage. Expansion of the industry to the Great Lakes and the Northeast may be expected in the next several decades to utilize the large inventories of hardwoods growing in those regions.

Product Mix and Diversification

Product diversification is another factor that may be important to the growth of forest products firms. The largest firms tend to produce both pulp and paper and solid wood products. Only 12 of the largest 40 companies specialize in one or the other. Smaller firms often specialize in particular items.

Diversification outside the industry, however, appears to offer no particular advantage.[49] During the past 30 years, a number of energy, packaging, and conglomerate firms have entered the forest products industry to diversify their operations. The financial performance of these diversified companies in terms of stock performance, growth, and profit is not clearly better or worse than the performance of companies whose major line of business is wood-based.

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[41] U.S. Congress, Office of Technology Assessment, *Current and Future Uses of Wood,* vol. II 1983, draft.

[42] Ibid.

[43] Thomas P. Clephane and Jeanne Carroll, *Timber Ownership, Valuation, and Consumption Analysis for 87 Forest Products, Paper, and Diversified Companies* (New York: Morgan Stanley Investment Research, 1980), p. 4.

[44] *An Analysis of the Timber Situation,* op. cit., p. 149.

[45] O'Laughlin and Ellefson, "U.S. Wood-Based Industry Structure," op. cit., p. 56.

[46] Clephane and Carroll, *Timber Ownership, Valuation, and Consumption Analysis,* op. cit., pp. 3-4.

[47] Ibid., pp. 58-93.

[48] Jean S. Moorefield, *Draft—Forest Products Industry: Socio-Economic Issues Related to Industry Expansion,* contract report to the U.S. Congress, Office of Technology Assessment, 1982, p. 14.

[49] Jay O'Laughlin and Paul V. Ellefson, *New Diversified Entrants Among U.S. Wood-Based Companies: A Study of Economic Structure and Corporate Strategy,* Station Bulletin 541, Forestry Series 37 (St. Paul, Minn.: University of Minnesota Agricultural Experiment Station, 1982), p. 25.

Sensitivity to Economic Activity

There are major differences in how the solid wood products and the pulp and paper sectors respond to economic conditions. Because pulp and paper firms make a variety of products for a diverse mix of end uses, their growth pattern follows that of the general economy.[50] Such is not the case for solid wood products companies. Nearly half of the lumber and panels produced are used in new residential construction. The homebuilding industry, in turn, may be the most volatile and unstable industry in the United States, as it is extremely sensitive to a number of economic and financial variables.[51] Thus, the solid wood products sector is also volatile, which may explain why the dominant firms often make a mix of paper and solid wood products rather than rely exclusively on one product line.

Innovation

The forest products industry has a modest record in developing new products and entering new markets. It devotes most of its research and development effort to internal process innovation.

Three components of the lumber and panel products sector are among the 45 rapid growth industries whose compound annual growth rates were between 6 and 20 percent during the period from 1972 to 1978. These components included wood pallets and skids, wood kitchen cabinets, and structural wood members (e.g., laminated beams and arches). Most rapid-growth industries attribute their success to new product development, but this does not appear to be true for the forest products industry. Historically, new products from the forest products industry have replaced established wood products rather than other materials, and many markets formerly dominated by wood products have been eroded by nonwood materials.

Reliable figures on the level of effort and type of research supported by the forest products industry are unavailable (see p. ______ for discussion of research and development). It is unusual for mature industries like the forest products industry to be dynamic and innovative. The industry is primarily "resource" oriented. Therefore, innovation seems to be generally confined to exploring new uses for wood rather than how wood might be used in conjunction with other materials.

Regional Distribution

Primary wood processing facilities generally are found where raw materials are most plentiful—on the Pacific coast and in the South. Lumber and plywood panels usually are manufactured in the Pacific Northwest and the South, and nonplywood panel products manufacture is concentrated in the Great Lakes States and the Northeast. Most pulp and paper manufacturing occurs in the South, and secondary paper products are made mainly in the Northeast, both near the largest markets. Location of secondary manufacturing facilities also depends on transportation costs and other factors.

Lumber

Ninety-four percent of lumber is produced in the South and the West, where high-quality softwoods are abundant. There are more mills in the South, but Western mills are generally larger and produce over two-thirds of the total U.S. lumber output. The North and East produce only 6 percent of the total U.S. lumber output (fig. 16).

Plywood and Other Panels

The plywood industry requires high-quality softwood logs, and therefore it too is located primarily in the South and West. Plywood panel production, now about evenly divided between the South and Pacific coast, has been growing rapidly in the South since the early

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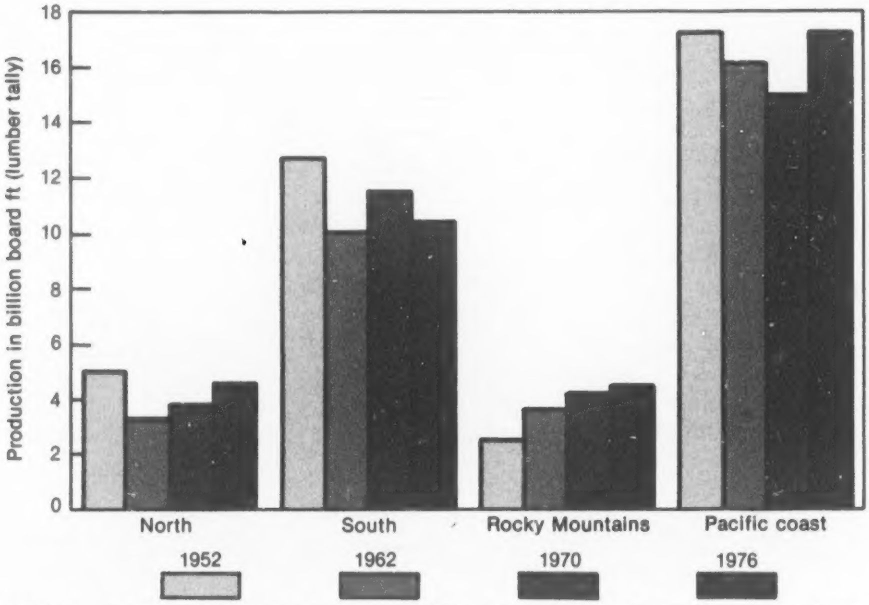
[50] *1982 U.S. Industrial Outlook*, op. cit., p. 39.

[51] Kidder, Peabody & Co., *Forest Products Industry*, pp. 5-13.

Figure 16.—U.S. Lumber Production by Region, 1952-76



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030*, Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), p. 220.

1960's (fig. 17). In 1979, the Pacific coast produced nearly 47 percent of all U.S. plywood panels, the South 42 percent, and the Rocky Mountain States the remainder.

Plywood accounts for about 96 percent of all panel production. Most of the expansion in the panel products industry, however, is in nonplywood, unveneered panels like waferboard and oriented strand board. Manufacturing capacity for these products is in the North Central and Northeastern States and future growth is expected to center there.

Pulp and Paper

Over half of America's pulp and paper manufacturing capacity is concentrated in the South, whose share of total pulp production was 48 percent in 1947 but grew to 69 percent by 1976. The West produced 17 percent of the Nation's pulp in 1976; the remaining 14 percent came from the East and North Central areas.[52]

Sixty-two percent of the secondary manufacturing capacity of the paper industry, which makes containers, bags, sanitary products, and stationery, is located near major markets in the New England, North Central, and Middle Atlantic regions.

Wood Fuel

Reliable data is not available on wood fuel producers, but their locations may be inferred from patterns of consumption. Since the low value of wood fuel does not encourage long-distance transport, production generally takes place close to consumers.

The North and South are by far the leading consumers of wood fuel (fig. 18), with residential and industrial/commercial use at its greatest in these regions. High levels of home fuelwood consumption in the North probably reflects the abundance there of inexpensive low-quality fuelwood used for heating, and in the South they reflect the paper industry's burning of wood waste to power its mills.

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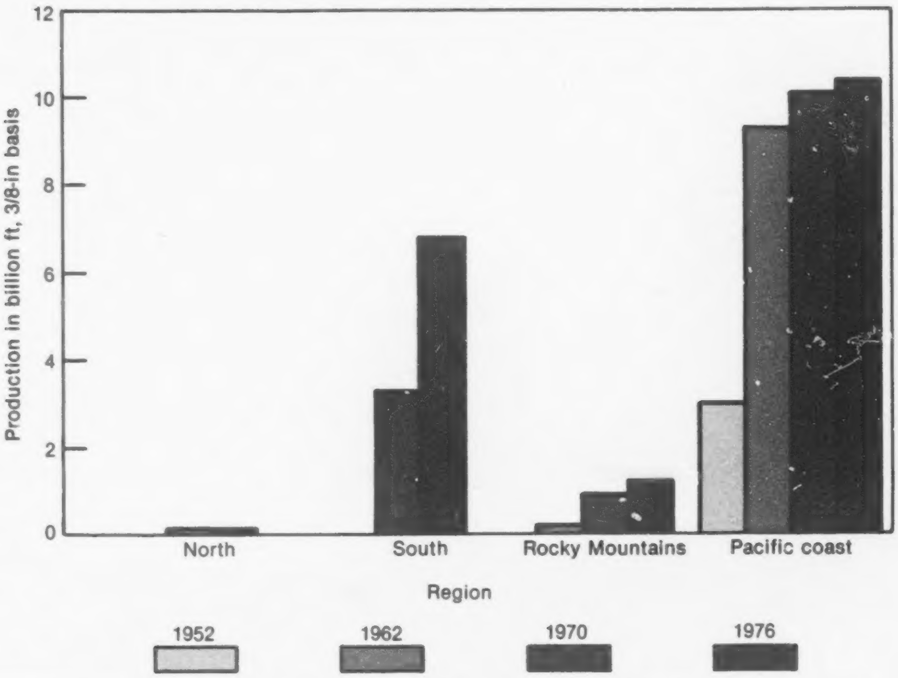
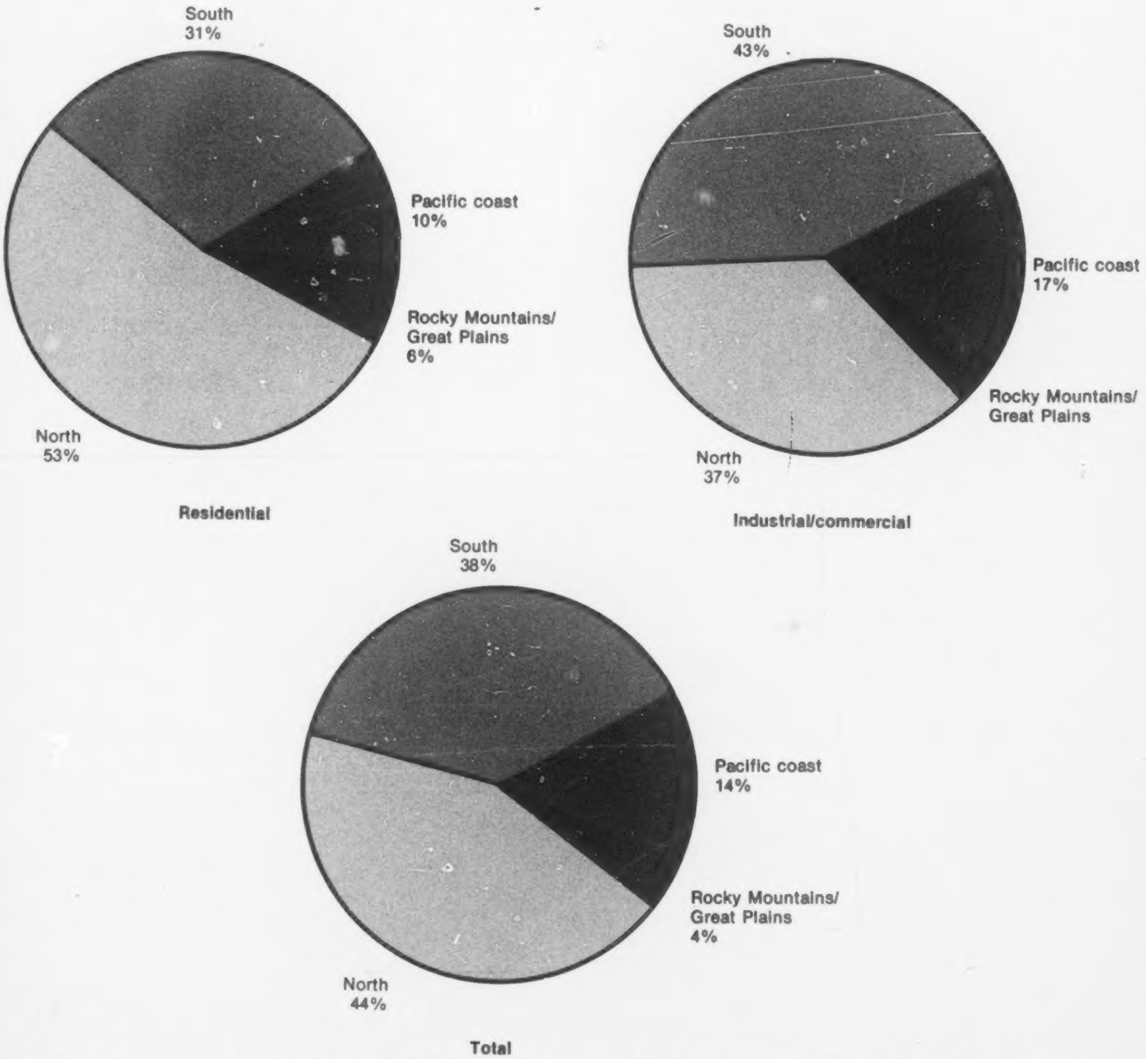
[52] Joan E. Huber, *The Kline Guide to the Paper Industry* (Fairfield, N.J.: Charles H. Kline & Co., 1980), pp. 39-40.

Figure 17.—Softwood Plywood Production by Region, 1952-76



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030,* Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 1982), p. 222.

Figure 18.—Regional Wood Fuel Consumption in 1981



Residential

Industrial/commercial

Total

SOURCE: Energy Information Administration, U.S. Department of Energy, *Estimates of U.S. Wood Energy Consumption From 1959 to 1981*, DOE/EIA-03, Dist. Cat. UC-13 (Washington, D.C.: U.S. Government Printing Office, 1982).

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Technologies for Growing, Harvesting, and Using Wood

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CHAPTER V

Technologies for Growing, Harvesting, and Using Wood

Summary

The application of existing technologies to the entire cycle of forest products manufacture, from growing and harvesting trees through end use, offers major opportunities to extend domestic wood supplies. Economic considerations, however, will ultimately determine the degree to which they are applied.

Substantial increases in U.S. timber production could result from expanding known silvicultural practices and management technologies on suitable lands. "Economic opportunities" for intensified timber management may exist on 30 to 40 percent of all commercial forestland, according to recent studies by the Forest Industries Council and the Forest Service.[1] Net annual growth on these lands could be increased between 11 billion and 13 billion cubic feet (ft^3) per year through application of certain management practices, which could require an investment of $10 billion to $15 billion over 30 to 50 years. Most of the opportunities identified involve planting and management of softwoods, often at a cost of more than $100 per acre. Hardwood management opportunities have yet to be assessed comprehensively.

The area of forestland that is likely to be managed intensively is probably much less than all the land that is economically qualified. Although 30 to 40 percent of the forestland base may be suitable for profitable timber management, bringing these lands under such management may be difficult. Private investments in intensive forest management compete with alternative investment opportunities, many of which have less risk, higher rates of return, and earlier payoffs.

The "economic opportunity" estimates do not reflect site-specific limitations such as conflicting landownership objectives, small parcels, lack of markets, and site conditions that make management difficult. These barriers to intensive management are discussed in detail in chapter VI.

Existing and emerging harvesting technologies and systems could expand timber supplies by enabling recovery of wood now left in the forest and by allowing harvest from tracts now considered inoperable. Conventional harvesting systems now leave substantial quantities of industrially usable material in the forest at harvest because the cost of removal exceeds the value of the product. In 1976, about 1.4 billion ft^3 of growing stock logging residues were left on-site as well as two to four times as much material in tops, branches, rough and rotten trees, and small stems. Salvageable dead timber also contains potentially usable woody material. In addition, some land is excluded from harvest because of such constraints as remoteness, difficult terrain, small tract size, and potential for environmental damage. Development of harvesting technologies and systems to overcome these problems would increase recoverable timber resources.

A major opportunity for increasing harvesting efficiency may be through a systematic, integrated approach to growing, harvesting, and transporting wood for processing. More effective use of equipment, improved harvesting practices, better training of woodsworkers, and more efficient transportation of wood to mills could improve productivity significantly. New harvesting systems also could reduce the potential for environmental damage. Over the long term, silvicultural systems for growing wood and technologies for harvesting and processing it could be designed to optimize the use of timber resources on a continuous basis.

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[1] U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the U.S., 1952-2030* (Washington, D.C.: Government Printing Office, 1982), p. 248; and Forest Industries Council, *Forest Productivity Report* (Washington, D.C.: National Forest Products Association, 1980), p. 46.

Creative "small tract" harvesting technologies and systems could enhance the potential contribution of private nonindustrial forests (PNIF) to national timber supplies. About 20 percent of the private forestland base is composed of parcels of less than 100 acres—tracts too small for efficient use of large harvesting machinery. In addition, improper harvesting operations sometimes discourage landowners from harvesting timber from their land because of damage to remaining trees, impairment of scenic qualities, and injury to the environment. Appropriate technologies and harvesting systems specifically adapted to small tracts and the diverse objectives of small landowners could expand potential harvest levels from the PNIFs. While small-tract systems are well developed in Sweden and other Western European nations where most forestland is in small parcels, they have not been widely adopted in this country.

Public and/or private entities will need to place greater priority on the development and use of improved harvesting systems if their potential is to payoff. Areas deserving attention include harvesting research and development (R&D), alleviation of environmental impacts, proper training of woodsworkers in the use of new systems and machinery, landowner education programs, transfer of proven technologies, and overcoming institutional barriers. Countries like Sweden have improved harvesting productivity significantly through cooperative public and private efforts, but less than 2 percent of the Forest Service's R&D budget in 1976 was applied to harvesting and only about 70 scientist-years of effort were dedicated to it. A similar pattern exists in academic research.

Utilization technologies may expand the use of currently abundant hardwood species and enable the use of low-quality woody material now underutilized or wasted. Several existing technologies permit the manufacture of new high-performance wood products from currently underutilized materials and species that could substitute for goods requiring more expensive and scarcer trees. Softwoods, because of their favorable properties, are now preferred for most high-volume conventional products such as lumber, plywood, and some grades of paper, and manufacturing processes have been tailored to them. Yet, over one-third of the total volume of existing U.S. timber is hardwood, and hardwood inventories are increasing much faster than softwoods. Existing and emerging technologies can overcome many deficiencies in hardwood properties and can enable the manufacture of many products from hardwoods that are now predominantly made from softwood. Saw-Dry-Rip, composite lumbers, and particleboard made from hardwoods could substitute for softwood lumber and plywood. Advances in mechanical and chemomechanical pulping technologies, coupled with newly developed processes for manufacturing press-dried paper, could expand significantly the use of hardwood for making paper and paperboard in time.

The U.S. forest products industry now wastes very little wood in actual manufacturing. As a whole, the industry uses up to 96 percent of its delivered wood, which is either converted into products or burned for process energy. Despite this high average utilization rate, some plants are not able to produce a product mix of the highest value now technologically possible because their equipment is older and less efficient. As new milling facilities replace the old, energy-efficient, higher yield technologies can enhance the industry's productivity and improve product values.

Wider use of currently available technologies, such as computer-assisted milling, could reduce requirements for roundwood per unit of lumber and panels by 20 percent or more. Nearly half of all industrial wood products are lumber and structural panels, so increased yields from these products alone could have a major impact on the domestic wood supply. However, increased yields also would reduce

Photo credit: U.S. Forest Service

The forest products industry now uses nearly all wood entering mills for products or energy. These sawmill residues are being loaded for transport to a pulpmill

the amount of wood residues available for energy generation in lumber and pulpmills. Replacement of such materials by recovery of additional forest residues and biomass at harvesting may then become more widespread. Tradeoffs between improved wood use efficiency and wood fuel production will change in tandem with relative changes in energy and product prices.

Existing and emerging manufacturing processes could improve energy utilization. The forest products industry now fills a substantial portion of its energy needs from wood. The pulp and paper sector in particular consumes an enormous amount of energy—over 2 quadrillion Btu in 1981—and furnishes about half of it by burning processing residues.

Expanded use of mechanical pulping technologies can conserve both energy and the timber resource by recovering more wood fiber than can chemical pulping. However, longer term improvements in chemical pulping, which now requires large amounts of energy, could reduce energy needs and may even produce additional energy for outside sale. Press-drying paper technologies may also reduce energy requirements when commercialized. Biotechnologies, now in the laboratory stage of development, could be potentially important in pretreatment or digestion of wood prior to pulping, thus improving yields and further cutting energy requirements. In addition, in lumber and panel manufacturing, improvements in drying technologies could reduce energy needs.

Improved end use of wood materials also could conserve timber supplies. For example, a significant reduction in wood needed for residential housing on a per unit basis is possible through the use of innovative construction techniques and designs that are currently available but not widely applied. Two of the major obstacles to adoption of these innovations by builders are outdated building codes and homebuyers' conservative tastes.

About one-fourth of the paper pulp produced in the United States comes from recycled paper. The practical upper limit for the proportion of recycled paper in finished paper is being increased regularly as new technologies are developed. The potential to achieve such increases is affected by the costs added for the removal of glue, ink, and other contaminants and by economic barriers to collecting waste paper outside of metropolitan areas. Paper and paperboards suitable for many uses can be produced from pulp composed almost entirely of recycled fibers.

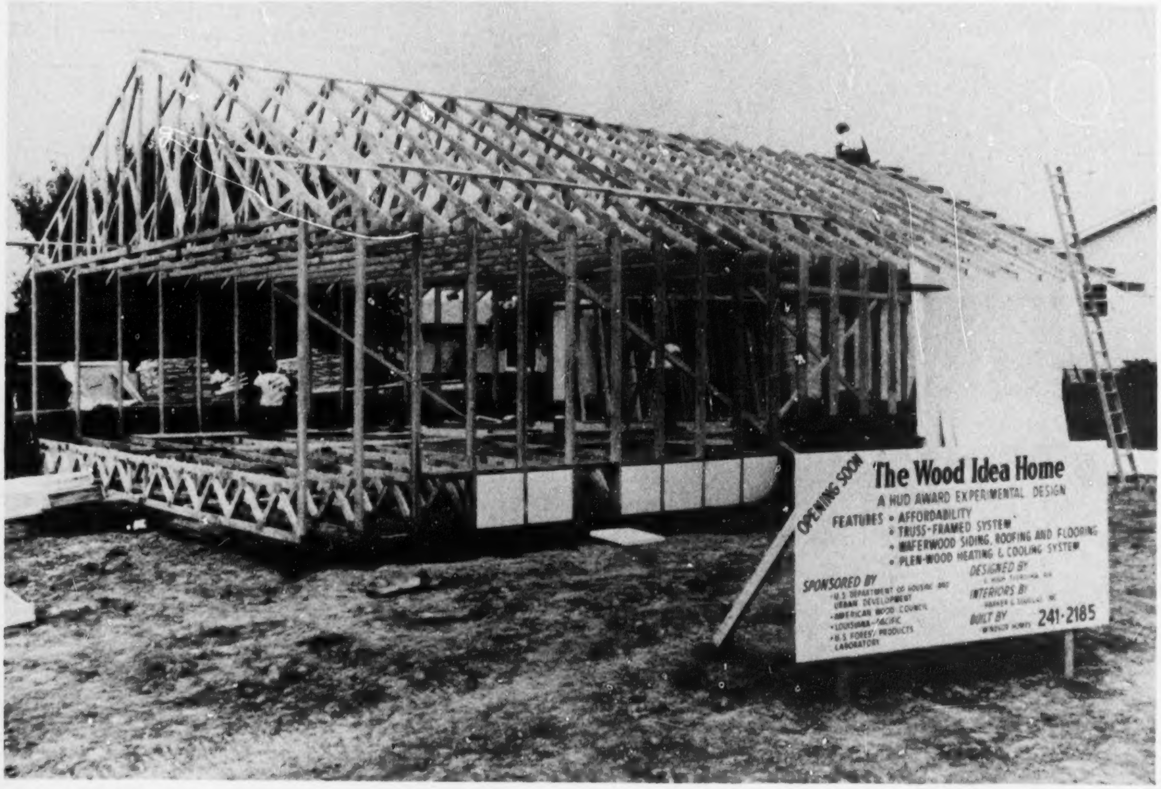

OPENING SOON
The Wood Idea Home
A HUD AWARD EXPERIMENTAL DESIGN
FEATURES • AFFORDABILITY
• TRUSS-FRAMED SYSTEM
• WAFERWOOD SIDING, ROOFING AND FLOORING
• PLEN-WOOD HEATING & COOLING SYSTEM
DESIGNED BY
SPONSORED BY
• U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
• AMERICAN WOOD COUNCIL
• LOUISIANA-PACIFIC
• U.S. FOREST PRODUCTS LABORATORY
INTERIORS BY
BUILT BY
241-2185

Photo credit: U.S. Forest Service

Residential construction is the single largest use for solid wood products. This house is being constructed with a truss frame system developed by the Forest Products Laboratory of the U.S. Forest Service, and a wood foundation which uses the subfloor as a heating and cooling plenum

Increasing Timber Supplies by Intensive Timber Management

Trees now growing will provide most of the timber available for harvest over the next 30 to 50 years. Beyond this, long-term increases in timber supplies will vary considerably among geographic regions and tree species, but will depend mainly on the area of land under management and timber growth rates per unit area. The area of commercial forestland that can respond profitably to investments in intensive management is a function of such factors as climate, soil, topography, and the land's proximity to wood processing facilities.

Unmanaged forests are generally composed of tree communities (stands) best adapted to local ecological conditions. Such stands may produce large quantities of tree biomass, including deformed stems, roots, limbs, and foliage in addition to merchantable stems, but do not necessarily provide industrially useful wood at optimal growth rates. In managed forests, silvicultural technologies—practices that cultivate tree crops by controlling forest composition and growth—are employed to enhance yields of industrially preferred species with usable trunks and stems. Other objectives, such as maintenance of wildlife habitat, watershed management, and esthetics, can be integrated into timber management strategies but are not discussed here.[7]

Distinctions between tree biomass and industrial-quality wood are important in assessing U.S. wood inventories. Such distinctions are not static, however, because changes in manufacturing technologies can broaden utilization standards and the range of sizes and species that are acceptable. Technologies that use material previously considered undesirable could effectively increase existing industrial timber supplies. For example, wood fuel can be obtained from a broader spectrum of tree biomass than roundwood alone, and some silvicultural systems have been developed to maximize biomass production for this purpose.

Ideally, a tree crop is harvested when it reaches the size required by utilization standards and its growth rate has slowed. The series of silvicultural treatments is then repeated for another rotation (or the interval between harvests in a managed system). The optimum number, sequence, and timing of treatments depend on the species, site conditions, and end product. For example, Douglas-fir in the Pacific Northwest and loblolly pine in the Southeast, probably the two most important U.S. timber species, require very different treatment systems.

One or more of eight silvicultural technologies may be used in a single timber rotation:

1. harvesting;
2. site preparation;
3. reforestation;
4. control of fire, competition, and pests;
5. precommercial thinning;
6. fertilization;
7. commercial thinning; and
8. genetic improvement.

Harvesting Methods

Harvesting is often considered the first step of a silvicultural system, because it affects the successful establishment of new stands. The best harvesting method depends on the reproduction requirements of the tree species desired in the next crop. Most softwoods, for example, require full sunlight for optimum growth and regenerate best when an entire stand is harvested all at once. In contrast, many hardwoods are "shade tolerant" and reproduce well when only part of a stand is removed.

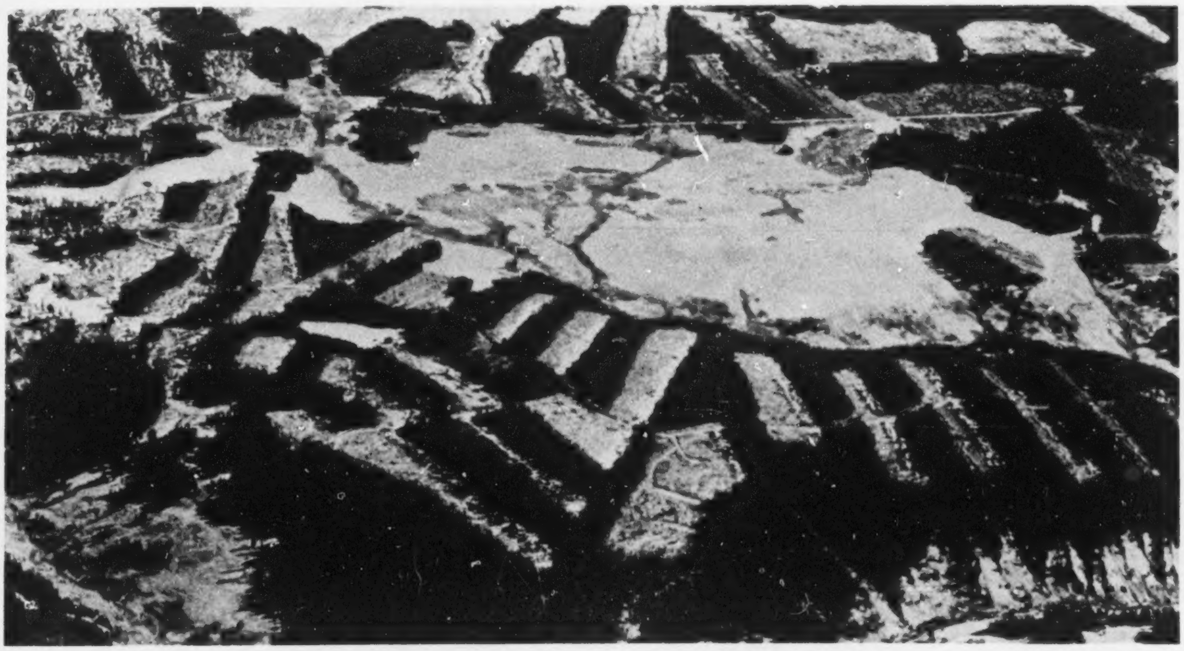
Clearcutting—removal of all commercial trees—is the preferred harvesting method for most commercial softwood species, including Douglas-fir and loblolly pine. It is also commonly applied to even-aged hardwoods such as aspen. When properly conducted, clearcutting has several economic and management advantages:

- it results in even-aged timber stands that are uniform in size and can be used for the same product;
- it allows cost-effective harvesting because maximum volume is removed in one operation; and
- it provides for optimum regeneration of species that grow best in full sunlight.

There are also possible disadvantages to clearcutting:

- regeneration of single-aged, single-species stands (monocultures) can increase their susceptibility to widespread insect or disease damage;
- uniform stands may not provide desired kinds of wildlife habitat;
- total stand removal can be visually unattractive;
- intense logging activity can cause soil erosion and stream sedimentation if improperly conducted; and
- removal of all streamside trees may cause temporary increases in water temperature, possibly affecting aquatic life until stream margins regenerate.

Most of these disadvantages can be mitigated by advanced planning to minimize visual impacts, locating logging roads to minimize soil losses, reservation of "buffer strips" along streams, maintenance of wildlife areas, and limiting the size of the harvest area.



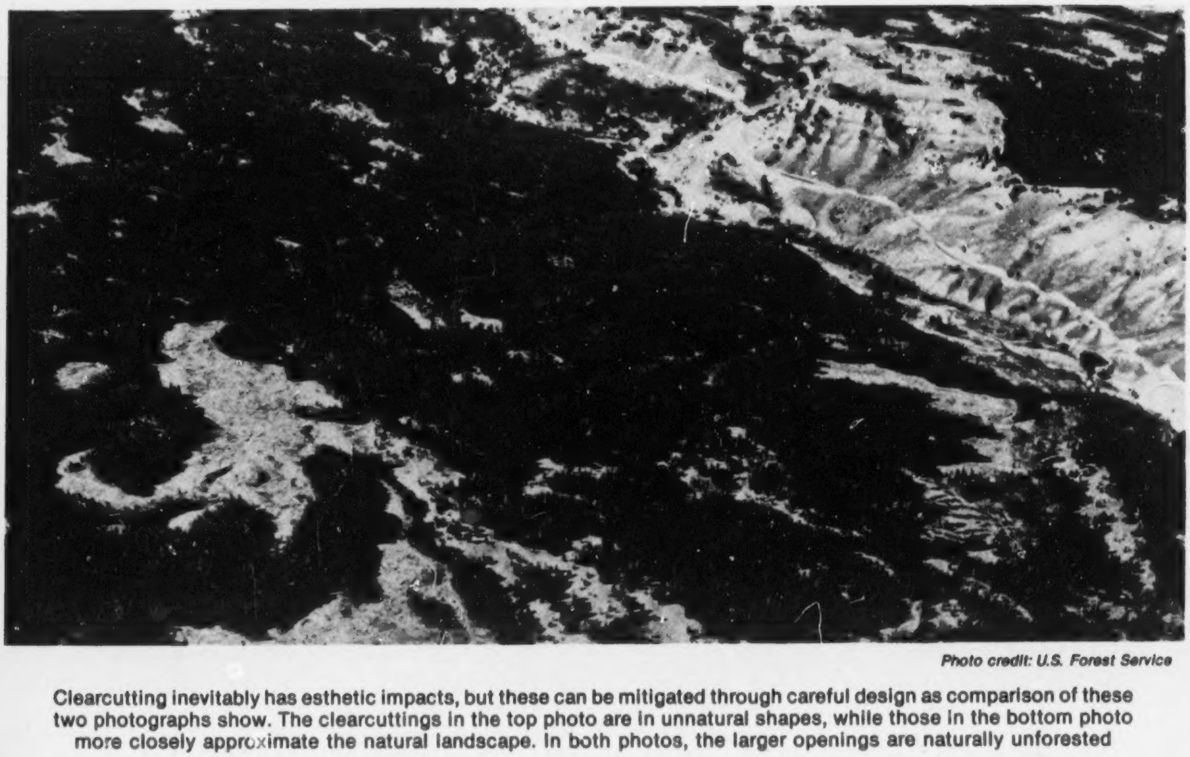


Photo credit: U.S. Forest Service

Clearcutting inevitably has esthetic impacts, but these can be mitigated through careful design as comparison of these two photographs show. The clearcuttings in the top photo are in unnatural shapes, while those in the bottom photo more closely approximate the natural landscape. In both photos, the larger openings are naturally unforested

Partial cutting methods are less common than clearcutting and are less important for industrial timber supplies. Selective cutting (a type of partial cut) involves harvest of a stand's largest crop trees and its "weed" trees to give the residual stand more room to grow. Selective cutting results in an uneven-aged (various-aged) stand and is conducted at intervals on a continuing basis as trees reach crop size. Seed-tree or shelterwood cutting removes all commercial trees except selected "seed trees," which are left to provide seed for the next stand and sometimes to provide shelter from wind or intense sunlight. Seed trees are often harvested after the new stand is established.

A relatively new application of a centuries-old harvesting method—the **coppice system**—allows stumps to resprout for successive fast-growing wood crops from the same root system. It is sometimes used for small-diameter hardwoods intended for fuelwood or chips and is expected to become more popular as new manufacturing technologies allow greater use of small hardwoods.

Site Preparation

Site preparation is often required for successful establishment of a new stand. It involves the clearing of unwanted vegetation or debris and in some instances the cultivation of an area prior to regeneration. By exposing bare soil so that seeds or seedlings can become established and by reducing competition from noncrop vegetation, site preparation optimizes conditions for new growth. It is especially valuable in eliminating competing hardwood trees and shrubs when hardwood stands are being converted to softwoods.

There are four site preparation methods that can be used for Douglas-fir and loblolly pine. The methods include mechanical treatment, prescribed burning, herbicide application, and combinations of these.

In **mechanical site preparation,** competing vegetation is physically uprooted, chopped, and/or removed by heavy equipment. This is sometimes followed by disking, harrowing, or bedding. Mechanically prepared sites can be burned or treated with herbicides to further reduce competition. Because mechanical site preparation removes organic matter and causes significant soil disturbance, concerns have been raised over its potential effects on the long-term productivity of the site. In some cases, mechanical site preparation results in soil losses from erosion.[2] In others cases, the use of heavy equipment may cause soil compaction.[3] The long-term effects of repeated site preparation on productivity will vary considerably depending on the soil, topography, and ground cover.

The use of **prescribed burning** to expose the soil and control competing vegetation is among the oldest and least expensive site preparation methods. It is widely used in the South for southern pine species and in the West for Douglas-fir. An area may be burned either before or after harvesting to remove fuels and limit the risk of wildfire or to control unwanted vegetation that often flourishes after crop trees are removed. Under certain atmospheric conditions, prescribed burning can significantly lower local air quality. Forest fires, including both wildfires and controlled burns, constitute a significant source of particulate emissions nationwide and therefore are a major source of air pollution.[4]

Herbicide use has become more common over the last few decades for site preparation on large areas. The most commonly used herbicides are the phenoxies, such as 2,4,5-T; Silvex; 2,4-D; and 2,4-DP. Aerial application generally has replaced hand spraying techniques because in most cases it is less expensive. Some herbicides may be applied either before or after planting, but application of others is more restricted because of potential damage to young seedlings. Herbicides are widely used in the Pacific Northwest in the management of Douglas-fir and to a limited extent in the southern pine region.

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[2] As discussed in J. Douglass, "Site Preparation Alternatives: Quantifying Their Effects on Soil and Water Resources," in *Proceedings: Site Preparation Workshop, East Southeast* (Raleigh, N.C.: U.S. Department of Agriculture, Forest Service, and North Carolina Department of Natural and Economic Resources, 1977).

[3] However, there may be benefits from reduced competition for seedlings even though compaction occurs. See J. J. Stransky, "Site Preparation Effects on Soil Bulk Density and Pine Seedling Growth," *Southern Journal of Applied Forestry*, vol. 5, 1981, pp. 176-180, for a discussion.

[4] As discussed in J. Hall, *Forest Fuels, Prescribed Fire and Air Quality* (Portland, Oreg.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 1972), p. 44.

The widespread use of phenoxy herbicides has become a major public policy issue, particularly in the Pacific Northwest where public lands predominate. While human health considerations are central to the debate, other public concerns have focused on the relative costs and benefits of herbicide application compared to other site preparation methods. Site preparation studies have tentatively suggested that:

- a ban of phenoxy herbicides in the coastal Douglas-fir region could reduce annual Douglas-fir yields by 7 to 17 percent;
- careful planning and controls could significantly reduce the hazards of human exposure to herbicides;
- nonchemical site preparation methods, such as chopping, clearing or planting cover crops, may be almost as effective as herbicide treatment if properly conducted, but are likely to cost more; and
- many herbicides can replace phenoxies for site preparation, some of which cost more and may be more or less effective.[5]

Regeneration

Regeneration—the establishment of a new timber crop—is probably the most important phase in a silvicultural cycle. It establishes the stocking (density and volume) and kind of species in the stand and, when conducted promptly, minimizes the length of timber rotations. The three major regeneration methods are planting, seeding, and natural regeneration. The best regeneration method depends largely on species, site, and stand conditions after harvest. Douglas-fir, southern pine, and some eastern hardwoods often are planted after clearcutting.

Planting involves setting seedlings in the soil, either by hand or by machine. Use of containerized stock, i.e., seedlings grown and planted in small containers, is a relatively recent development that may improve seedling survival rates and reduce handling problems. Density, or the number of seedlings per acre, is an important aspect of planting because it influences the rate of growth, total timber volume produced, and individual tree size at the end of the rotation. In general, high-density stands produce smaller trees and higher total volumes, while low-density stands produce larger individual trees and lower total volumes.[6] Planting is generally the best method for establishing rapidly growing, genetically improved trees.

Regeneration by **seeding** can be accomplished through "seed trees" purposely left on the harvest area (see earlier discussion of harvesting methods) or from seeds that are collected and sown. Seeding is generally less expensive than planting, but the risk is greater that a fully stocked stand will not be established promptly. If supplemental planting or seeding is required and growth of the next tree crop is delayed, seeding can cost more than planting. Seeding can also result in high-density stands requiring precommercial thinning (see below), which significantly increases costs.

Natural regeneration is the renewal of tree crops from seeds or sprouts. In many instances, it simply amounts to letting nature take its course. In other instances, it may be part of a management strategy. Management actions, such as proper harvesting and site preparation, may be required to ensure successful reseeding. Seed tree and selection harvesting systems rely on natural regeneration to produce the next crop of trees.

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[5] A case study of herbicide issues in forestry can be found in K. Green, *An Evaluation of Herbicides, Forestry and People: A Western Oregon Case Study* (New York: Council on Economic Priorities, 1982).

[6] W. Harms and F. Lloyd, "Stand Structure and Yield Relationships in a 20-Year-Old Loblolly Pine Spacing Study," *Southern Journal of Applied Forestry*, vol. 5, 1981, pp. 162-165.

Competition, Fire, and Pest Control

While site preparation can control competing vegetation that invades an area immediately after harvest or planting, unwanted brush and grasses can redevelop and crowd out new trees before a stand becomes sufficiently established to compete effectively for growing space. Control of competition within 3 years after planting loblolly pine can result in growth increases of up to 300 percent.[7] Alternative competition control methods include herbicide application, hand cutting, and mechanical cultivation between trees.

Wildfire, insect, and disease control are important in maintaining a healthy and vigorous stand of timber. Insect control increasingly involves integrated pest management systems that can reduce losses from insects and disease through silvicultural methods, selective chemical pesticides, and improved detection and forecasting. Most U.S. forestland is now under organized wildfire control conducted on a cooperative basis by Federal, State, local, and private entities. Cooperative efforts also have played important roles in insect and disease control.

Precommercial Thinning

There is some evidence that thinning plantations precommercially (before they reach a marketable size) can increase wood production. Growth of loblolly pine and Douglas-fir has been improved by precommercial thinning.[8] [9] A disadvantage of precommercial thinning is that it requires expenditures without immediate cost recovery from wood sales, in contrast to thinning delayed until stands reach pulpwood size. Expanded use of fuelwood could make precommercial thinning more economical in the future.

Fertilization

Fertilization can increase wood production substantially for certain species and soil types. Fertilizer is most commonly applied aerially, often to large areas. Since the cost of fertilizer is tied closely to the cost of energy, the future extent of forest fertilization may depend on energy costs in relation to timber values.[10]

Nitrogen fertilization of Douglas-fir has become more widespread in the Pacific Northwest, and growth response varies with the rate of application and with site quality. Incremental growth increases from fertilization tend to peak 3 to 5 years after application, and detectable effects disappear completely after 10 or 15 years.[11] Research results suggest that maximum economic benefit is achieved when nitrogen is applied both 3 to 5 years before thinnings and before final harvest and that lower quality Douglas-fir sites may benefit more from fertilization than higher quality sites.

Loblolly pine may benefit from phosphorus and nitrogen fertilization, although some studies indicate a less consistent response. Fertilization of southern pines is not currently a common technique,[12] yet some firms have adopted it as a routine practice on responsive sites.

Following fertilization, nitrogen concentration in nearby streams can reach high levels, in some cases increasing growth of aquatic plants downstream from the fertilized area. Peak concentrations of nitrogen, however, seldom persist for more than a few hours and usually return to pretreatment levels within 3 to 5 days.[13] Environmental damage can be reduced if untreated buffer areas are left along streams, if fertilization is timed to avoid heavy storms or snow melt, and if fertilizer is applied during periods of low wind and good visibility so that placement can be well controlled.[14]

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[7] L. Nelson, C. Pederson, L. Autry, S. Dudley, and J. Walstand, "Impacts of Herbaceous Weeds in Young Loblolly Pine Plantations," *Southern Journal of Applied Forestry,* vol. 5, 1981, pp. 153-158.

[8] D. Reukema and D. Bruce, *Effects of Thinning on Yield of Douglas-Fir: Concepts and Some Estimates Obtained by Simulation,* General Technical Report PNW-58 (Portland, Oreg.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 1977), p. 33.

[9] R. Lohrey, "Growth Responses of Loblolly Pine to Pre-Commercial Thinning," *Southern Journal of Applied Forestry,* vol. 1, 1977, pp. 19-21.

[10] S. Gessel, R. Kenedy, and W. Atkinson, *Proceedings of Forest Fertilization Conference* (Seattle, Wash.: University of Washington, College of Forest Resources, 1981).

[11] See R. Miller and R. Fight, *Fertilizing Douglas-Fir Forests,* General Technical Report PNW-83 (Portland, Oreg.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 1979), p. 29.

[12] H. W. Dugan, and H. L. Allen, "Estimating fertilizer response in site-prepared pine plantations using basal area and site index," in *Proceedings of the First Southern Silviculture Resource Conference* (Washington, D.C.: U.S. Government Printing Office, 1981,) p. 219-232, USDA Forest Service General Technical Report 50-34.

Recent investigations have tested the potential for increasing nitrogen on poor sites by growing Douglas-fir in association with red alder, which adds nitrogen to the soil through the action of bacteria occurring naturally on its roots. Preliminary results suggest that the largest **total** volume of both species may be produced by growing red alder for 13 years, removing it, and growing Douglas-fir for 45 years.[15] However, maximum economic return still comes from growing Douglas-fir without the alder rotation, because the current value of red alder is relatively low.

Commercial Thinning

Commercial thinnings—removals of usable trees to give the residual stand more room to grow—ideally are made on a 5- to 7-year basis in both Douglas-fir and southern pine. The first commercial thinning in Douglas-fir is usually applied between ages 25 and 30 and in the southern pines between ages 15 and 20. Commercial thinning maintains optimum spacing to ensure desired tree size at harvest and provides intermediate investment returns.

Heavy thinning may shorten the time required for final crop trees to reach a specific size. However, the maximum amount of wood from both thinnings and mature trees probably can be produced by removing only the number of trees that are likely to die naturally during the rotation. Manufacturing technologies that allow use of smaller trees could make tree size less important and lead to longer intervals between thinning or to shorter rotations.

Genetic Tree Improvement

Planting of genetically improved seedlings ultimately may increase future timber yields greatly. Since the early 1950's, programs to develop genetically superior trees have been undertaken by industry, government, and academic institutions. Most of these efforts have focused upon Douglas-fir and loblolly pine. First generation tree breeding efforts were aimed at producing progeny from trees of superior form and growth (superior trees). Second generation efforts have cross-pollinated or cloned superior trees to produce improved planting stock.

Increases of 10 to 45 percent in the annual growth of Douglas-fir plantations have been reported from the use of improved planting stock.[16] Increases of 40 to 80 percent in southern pine growth rates also have been reported.[17] Genetic improvement appears to be more advanced in the South than in other timber producing regions, although all regions are working on its development.

Optimal growth levels are achieved when plantations of genetically improved trees are intensively managed under a silvicultural regime. Such management approaches dramatically boost productivity over what could be expected on natural sites. According to one estimate, improved planting stocks and existing technology could improve Douglas-fir production by 70 percent and loblolly pine by 300 percent, but these gains are still less than half of theoretical maximum productivity levels (fig. 19). Further gains could be made through additional advancement in tree genetics and refinement of management technologies.

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[13] D. Moore, *Effects of Fertilization with Urea on Stream Water Quality*, Research Note PNW-241 (Portland, Oreg.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, 1975), p. 9.

[14] L. Norris and D. Moore, "The Entry and Fate of Forest Chemicals in Streams," in J. Krygier and J. Hall (eds.), *Proceedings of the Symposium on Land Uses and Stream Environment* (Corvallis, Oreg.: Oregon State University, 1971), pp. 138-158.

[15] W. Atkinson, B. Bormann, and D. DeBell, "Crop Rotation of Douglas-Fir and Red Alder: A Preliminary Biological and Economic Assessment," *Botanical Gazette*, vol. 140 (Supplement), 1979, pp. 5102-5107.

[16] W. Hyde, *Timber Supply, Land Allocation and Economic Efficiency* (Washington, D.C.: Resources for the Future, 1980), p. 223.

[17] W. Dorman and B. Zobel, *Genetics of Loblolly Pine*, Research Paper WD-19, (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1973).

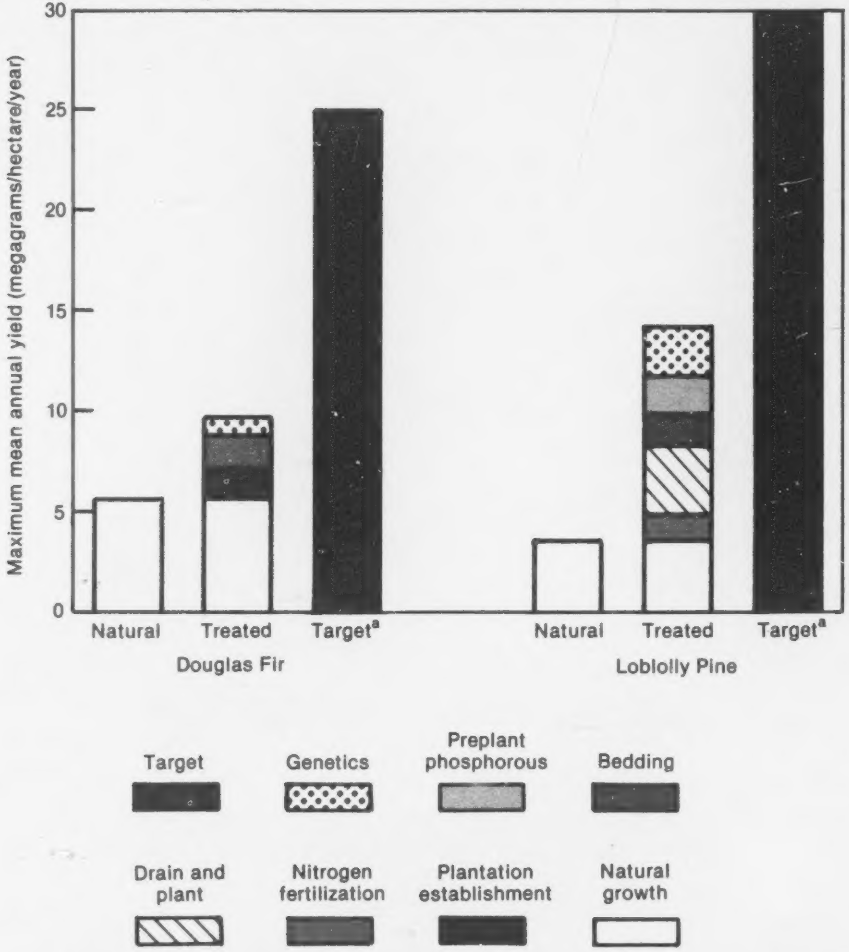
Photo credit: USDA Soil Conservation Service

Commercial thinning is used to achieve desirable spacing of trees, and also provides landowners with income

Occasionally, the crossing of tree strains produces hybrids that grow faster, produce higher quality wood or have better form than either parent tree. Such hybrids can be reproduced from cuttings (cloned) to supply large quantities of superior planting stock. Poplars probably have been the most successful tree hybrids. Clones developed from cuttings from conifer species show gains in productivity, but several problems have been identified, including difficulties in propagating cuttings from trees old enough to show superior characteristics. Clones developed for superior growth often have less capacity to accommodate environmental variations and may be more subject to damage from disease and climatic extremes than trees produced from wild seeds.

The potential of genetics to improve growing stocks has not been realized as quickly in silviculture as it has in agriculture because of the long growing cycle of trees. Genetic improvement of tree species requires far longer testing periods than for agricultural crops, and the establishment of improved trees in plantations is an incremental process. The long time period (5 to 20 years) before trees reach seed-

Figure 19.—Productivity Increases Attributable to Intensive Management



[a] "Target" values for maximum mean annual yield were defined through a theoretical model and observations from existing stands. The targets are estimates of mean annual yields potentially achievable on plantations established at the end of the century, assuming advancements in cultural and genetic technologies.

SOURCE: Adapted from Peter Farnum, et al., "Biotechnology of Forest Yield," *Science*, 2/11/83, p. 697.

bearing age has slowed progress in tree breeding using traditional techniques. The corresponding commercial application of these advances has taken 50 years or more in the past because of the repeated breedings necessary to establish useful strains.

Advances in biotechnology may accelerate this process greatly.[18] For example, mass propagation of superior clones through tissue culturing is a potentially important development in forest genetics. Tissue culturing entails in vitro propogation of living cells in a supportive medium that maintains their viability. Some forest products firms now are field testing mass propagation of clones produced through tissue cultures that have been planted in natural conditions.

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[18] *Impacts of Applied Genetics: Micro-Organisms, Plants, and Animals* (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-HR-132, April 1981), describes new plant breeding technologies in detail.

Photo credit: Simpson Timber Co.

Tissue culturing has important implications for forest genetics. Tissue cultured clones (such as the redwood plantlets shown above) are now being field tested by some forest products firms

Short Rotation Hardwood Culture

Improved techniques for hardwood management have received comparatively less attention than management of softwood species. An important exception is short rotation intensive hardwood culture aimed at production of biomass for energy.

The oil shortages of the early 1970's drew attention to the wood fuel potential of fast-growing trees produced in intensive agricultural-like systems. While both softwoods and hardwoods have been tested, fast-growing hardwoods such as hybrid poplar, cottonwood, willow, and sycamore appear to be the most promising. These species are less expensive to regenerate because they can be propagated from cuttings and can reproduce from stump sprouts after successive harvests (coppice systems).

Combinations of genetic improvement,[19] site preparation, cover crops which reduce competition, cultivation,[20] fertilization,[21] and irrigation[22] may be used to increase biomass production. Biomass yields from intensively cultivated 4- to 5-year-old hardwoods may yield 25 to 30 short tons per acre per year on the first rotation and volumes 30-percent greater on successive crops from the resprouted root systems.[23]

While early research has focused on biomass for energy, changes in wood utilization standards to allow the use of small timber and modifications in intensive hardwood culture to grow larger trees could lead to other products.[24]

Potential Gains From Intensive Timber Management

The Forest Service has compared current average net annual wood growth with potential growth that might occur in fully stocked natural stands, i.e., natural stands with optimal density and spacing (table 17). Net annual

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[19] See, for example, J. Ranney, J. Cushman, and J. Trimble, *The Short Rotation Wood Crops Program: A Summary of Research Sponsored by the Biomass Energy Technology Division*, draft report (Oak Ridge, Tenn.: Oak Ridge National Laboratory, 1982).

[20] See, for example, H. Kennedy, Jr., "Foliar Nutrient Concentrations and Hardwood Growth Influenced by Cultural Treatments," *Plant and Soil*, vol. 63, 1981, pp. 307-316.

[21] See, for example, T. Bowersox and W. Ward, "Economic Analysis of a Short Rotation Fiber Production System for Hybrid Poplar," *Journal of Forestry*, vol. 74, 1976, pp. 750-753.

[22] See, for example, D. H. Urie, A. R. Harris, and J. H. Cooley, "Irrigation of Forest Plantations with Sewage Lagoon Effluents," in *State of Knowledge in Land Treatment of Wastewater*, vol. II of proceedings from 1978 Conference at U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory, Hanover, N.H., pp. 207-213.

[23] M. Cannell and R. Smith, "Yields of Minirotation Closely Spaced Hardwoods in Temperate Regions," *Forest Science*, vol. 26, 1980, pp. 415-428.

[24] P. Larson, R. Dickson, and J. Isebrands, "Some Physiological Applications for Intensive Culture," *Intensive Plantation Culture*, General Technical Report NC-21 (St. Paul, Minn.: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, 1976), pp. 10-18.

Table 17.—Average Net Annual and Potential Growth Per Acre in the United States by Ownership and Section, 1976[a]

Item	Unit of measure	All ownerships	National forest	Other public	Forest industry	Farmer and other private
North:						
Current	Cubic feet	35	43	36	44	33
Potential	Cubic feet	66	63	59	74	66
Current/potential	Percent	53	68	61	59	50
South:						
Current	Cubic feet	57	57	54	60	56
Potential	Cubic feet	77	71	71	83	77
Current/potential	Percent	74	80	76	72	73
Rocky Mountains and Great Plains:						
Current	Cubic feet	29	30	25	50	25
Potential	Cubic feet	60	64	55	74	51
Current/potential	Percent	48	47	45	67	49
Pacific coast:						
Current	Cubic feet	49	30	53	80	62
Potential	Cubic feet	97	91	88	119	99
Current/potential	Percent	51	33	60	67	63
Total:						
Current	Cubic feet	45	35	42	59	45
Potential	Cubic feet	74	74	68	87	72
Current/potential	Percent	61	47	62	68	62

[a] Potential growth is defined as the average net growth attainable in fully stocked natural stands. Much higher growth rates can be attained in intensively managed stands.

SOURCE: Adapted from *An Analysis of The Timber Situation in the United States, 1952-2030* (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1982), p. 137.

growth on all commercial forestland in the United States in 1976 was estimated to be about 60 percent of potential if all forests were well-stocked natural stands. The Pacific coast had the highest potential production at 97 ft^3 per acre per year, but growth in 1976 was only about half of what it could have been.

Differences among timber species, site quality, available management techniques, and landowner objectives make it difficult to reliably estimate the absolute potential for increased timber production through intensive silviculture, but substantial increases in per-acre productivity clearly are possible if adequate investments are made.

Several factors determine whether a tract of land might be intensively managed for timber. These include its biological suitability as well as its economic suitability. Another factor is whether or not its owner is willing to make the investment and has the financial capacity to do so (see ch. VI for further discussion).

Both the Forest Industries Council (FIC), a trade group sponsored by the National Forest Products Association, and the Forest Service recently published estimates of acreage affording economic opportunities for management in 25 States.[25] [26] Both studies used standard discounted cash flow techniques. The financial feasibility of timber management was based on estimates of potential wood yields, management costs, and timber values that would produce a positive net present value at specified interest rates. The FIC study used a 10 percent rate of return criteria in calculating economic opportunities, while the Forest Service used a 4-percent rate of return. The Forest Service excluded national forests from its survey, while the FIC survey did not.

The 25 individual States that FIC analyzed contain together about 83 percent of the commercial forestland in the United States. Fifty-three percent of the land considered was determined to be **silviculturally** suitable for intensive management, and 34 percent was determined to be **economically** suitable (see table 18).

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[25] Forest Industries Council, *Forest Productivity Report* (Washington, D.C.: National Forest Products Association, 1980), p. 46.

[26] *An Analysis of the Timber Situation,* op. cit., p. 248.

Both studies concluded that the greatest potential for increasing timber production through intensive management is in the South, followed by the Pacific coast and the North. To achieve the projected potential gains, large amounts of capital would be required—an estimated total investment over a rotation cycle of $10 billion under the FIC study to $15 billion under the Forest Service study.

The FIC and Forest Service estimates of economic opportunities for management provide useful information given the limited data available. The projected economic opportunities, however, are probably higher than will actually be realized. Landowner objectives, for example, which on private nonindustrial forests (PNIF) lands are diverse and seldom include intensive timber management, were not considered, even though most of the projected potential increase was on PNIF properties (see ch. VI for discussion of PNIF ownership objectives). In addition, the studies considered all commercial forest tracts 1 acre in size and larger, but the possible effects of tract size on the economics of intensive forest management were not addressed.

Table 18.—Area of Commercial Forestland and Areas Suitable for Intensive Management in 25 FIC Study States (million acres)

	Commercial forestland	Silviculturally suitable land	Economically suitable land
Mississippi	16.9	11.5	11.2
Oregon	24.4	12.5	10.0
Arkansas	18.2	11.6	9.9
Louisiana	14.5	9.0	9.0
Georgia	24.8	12.8	9.0
Washington	17.9	9.4	7.6
Alabama	21.3	15.1	7.4
Texas	12.5	8.9	6.5
Florida	15.3	7.5	6.3
Virginia	15.9	7.1	6.3
California	16.3	10.0	6.2
Tennessee	12.8	6.6	6.0
Idaho	13.5	7.8	5.3
Michigan	18.8	7.4	5.0
West Virginia	11.5	7.2	4.9
Montana	14.4	8.1	4.9
North Carolina	19.6	13.6	4.5
South Carolina	12.2	7.3	3.6
Wisconsin	14.5	4.9	3.3
Missouri	12.3	9.2	3.1
Pennsylvania	17.5	2.8	2.4
Kentucky	11.9	8.3	2.1
Minnesota	16.1	4.5	1.7
Maine	16.9	6.8	1.4
New York	14.5	3.6	1.4
Total	404.5	213.3	139.0

SOURCE: Individual State Productivity reports prepared for the Forest Productivity Project of the Forest Industries Council, 1978-80.

Increasing Timber Supplies by Improving Harvest Technology

Improved harvesting systems could effectively increase timber supplies by removing more wood from harvest sites and by opening up areas that currently are too costly or environmentally sensitive to log. Key areas where improvement can be made include harvesting machinery, harvesting methods, woodsworker training, and improved integration of all aspects of harvesting into an organized system.

Developing new, innovative mechanical systems takes 7 to 10 years. Because of this timeframe, current timber characteristics and available technologies for timber extraction and processing will define harvesting systems in the next 30 years. In the longer term, it is possible to improve utilization and increase available wood fiber by designing integrated systems for growing, harvesting, and processing to achieve near-optimal results.[27]

Several factors affect the feasibility of increasing timber supplies through improved harvesting technology:

- characteristics of the forests to be harvested;
- opportunities for utilizing materials that harvest makes available; and
- environmental constraints.

Characteristics of U.S. Forests

Over the next 20 to 30 years, harvesting systems will reflect the quality and quantity of trees now growing. These characteristics vary significantly by region. In the East, average tree diameters are not expected to change much, while in the West a decline of 27 percent by 2000 has been projected.[28] Hardwood inventories are expected to accumulate in the North and the South; in the South, softwood production may increase on a per acre basis due to intensive management.

Ownership factors and the economics of extracting timber will also affect harvesting efficiency. For example, private nonindustrial lands are expected to account for an increasing portion of timber supplies. PNIF tracts are typically small in size, however, while most harvesting machinery is designed for large operations.

Beyond 2010, current and prospective intensive management practices could increase timber supplies and change the character of timber stands. Replacement of unmanaged stands with rapidly growing, genetically improved trees could result in smaller, less defective, and more uniform trees for harvest.

Utilization Opportunities

Recent technological advances in forest products manufacturing have increased substantially the opportunities for utilization of small logs, hardwoods, residues, and defective or rough timber. Some of the more important developments include:

- the use of low-quality wood as filler for panels and as center portions of laminated beams and studs,
- machines that peel smaller logs for plywood,
- processes that make panels from low-grade hardwood chips and flakes that can substitute for plywood in some applications, and
- new systems for efficient combustion of wood wastes.

Wider adoption of such processes could expand the use of materials now considered too costly to remove from the forest for use. According to the Forest Service,[29] 1.4 billion ft^3 of growing stock residues were left on harvest sites in 1976, along with two to four times as much material in the form of tops, branches, small stems, and other materials. About 14 billion ft^3 of potentially salvable accumulated dead timber existed in 1977, mostly western softwood. Commercial timberland also contains tens of billions of cubic feet of defective trees from commercial species. A greater portion of these materials may have economic potential for use in fuel and industrial applications in the future.

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[27] As discussed in G. W. Brown, W. R. Bentley, and J. C. Gordon, "Developing Harvesting Systems for the Future: Linking Strategies, Biology, and Design," *Forest Products Journal*, vol. 32, 1982, pp. 35-38.

[28] R. Haynes, D. Adams, and E. Bell. Manuscript on file at U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

[29] *An Analysis of the Timber Situation,* op. cit., pp. 264-266.

Environmental Limitations

Improper harvesting practices can cause serious environmental damage. New harvesting technologies and systems could exacerbate such impacts unless special care is taken in their design and operation. Harvesting systems that remove rough and rotten trees and dead timber over a large geographic area could affect adversely those wildlife species dependent on such trees for habitat. Also, operations that totally remove all the fiber produced on sites may further deplete nutrients in shallow, low nutrient soils, especially under short rotation systems. Some States have adopted forest practices laws designed to mitigate damage to soil, water quality, wildlife, and esthetic resources caused by harvesting.

New technologies and systems could be developed to overcome some of the constraints that presently prevent harvest of some forests. For example, about 185,000 acres of national forest timberland in the Pacific Northwest are excluded from the allowable cut base because of potential environmental problems associated with harvesting; systems that entail less damage could expand the acreage available. For many small landowners, small-scale systems that are well adapted to scenic and esthetic concerns could broaden the appeal of timber harvesting. Training of woodsworkers is also important for reducing environmental effects during harvest operations.

Technology Development Process

The development of harvesting technology in the United States has not been an integral part of the overall timber production system. For the most part, coordination of efforts among equipment manufacturers, timber producers, and processors has been limited, even on a regional basis.[30] Development of harvesting systems has not been supported as intensively by either private or public research in the United States as in Western Europe (see box B).

In the absence of a strong coordinated R&D process, the focus has been largely on individual machines rather than integrated systems. In this country, harvesting machinery is developed primarily in three ways:

- Trial and error—often by loggers. While innovation has sprung from this method, it usually produces designs that meet unique rather than general needs.
- Development in small job shops—sometimes in response to needs expressed by a logger client. These advancements often are not fully exploited because of limitations in the size of the production line, investment capital, and the engineering staff.
- Development by major equipment manufacturers. Contributions by large firms, while important, have been small in relation to their potential, partly because the construction and agriculture industries are their primary markets.

Current U.S. Harvesting Technology and Systems

In general, U.S. harvesting equipment is classified as either ground-based or aerial. Usually, this equipment is designed to "yard" or transport timber felled and limbed by chainsaw from stump to landing where it is loaded as a log onto a truck for transportation to the mill. Probably 90 percent of the wood fiber in the United States is processed in this manner. In the eastern half of the country, pulpwood is the main product, cut into 100-inch or 63-inch lengths. Small diameter trees are frequently sheared rather than cut by chainsaw and are often delimbed by pushing the stem through a gate. Trees are either yarded to the landing by skidders or are cut into pieces and loaded directly onto flatbed trucks. In the West, because logs are used predominantly for lumber or plywood, they usually are yarded in 25-ft lengths or longer.

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[30] As discussed in Brown, Bentley, and Gordon, "Developing Harvesting Systems for the Future," op. cit., pp. 35-36.

A description of yarding equipment and the performance characteristics of each type is presented in table 19.[31] Horses, tractors, wheeled skidders, and feller-buncher tree processors move logs across the ground surface. Aerial harvesting equipment (cables, skylines, balloons, and helicopters) provide lift to logs as they are delivered from stump to landing.

The cost of harvesting by these means varies widely depending upon the skill of the crew, the terrain, the timber size, and the size of the tract harvested. In general, ground-based operation cost less than aerial systems. For ground-based equipment, which is best suited to gentle terrain, costs are usually half those of aerial machinery. As a result, most industrial

Table 19.—Performance of Timber Harvesting Equipment

Horse	Tractors and wheeled skidders	Feller-bunchers tree processors	Cable and skyline	Balloon	Helicopter
Timber size capability					
Small timber generally less than 24" Dbh[a]	Capable of handling all sizes in design range of machine	Small to medium timber less than 24" Dbh[a]	Medium to big timber; small timber in thinnings	Timber weight limit	Timber weight limit
Production potential					
Low production	High production	High production possible	Medium to high production	Medium to high production; winds over 25 knots limit operability	Very high production but weather restricts operability
Costs of production					
Low	Low	Low to medium	Medium to high	High	Very high
Limits on silvicultural system					
None	None	Thinning in rows or strips possible	Generally clearcuts; partial cuts possible	Suited to clearcuts; experimental in partial cuts	No limitations
Topography limits					
Gentle; occasional short, steep pitches over 50%; downhill yarding preferred	Up to 35 to 45%; downhill yarding preferred	Up to 30%	Deflection necessary but suited to steep slopes	Adaptable to topography within limits	No limits
Road access requirements					
Haul road close to skid road (300′ to 500′ desirable)	Long skid distances feasible but not economical	Medium distances from haul road up to 1,500′	High lead logging 1,500′ approaching maximum yarding distance—some skyline operational at 5,000′	About 5,000 limit	No limit except by economy
Stream protection					
Generally excellent with proper practices	Can be excellent depending on proximity to stream and practices; crossings need preparation	Good with proper practices; stream crossings need preparation	High lead poor if logging across streams, otherwise good; skylines can lift log free of streams	Capable of lifting logs free of streams; large landings near streams are problems	Excellent protection
Site disturbance					
Minimum disturbance; little slash handling capability; small landings 50′ diameter	Medium to high disturbance; soil compaction potential; damage to residual stand possible; slash handling possible; medium landings approximately 75′ diameter	Medium to high disturbance; soil compaction potential; damage to residual stand possible; slash handling possible; medium landings approximately 75′ diameter	Minimum to medium disturbance possible with proper practices; slash handling possible; may damage residual stand in partial cuts; medium landings about 75′ diameter	Minimum disturbance; slash handling a problem; requires 100′ diameter landing + 200′ diameter tie down area	Minimum disturbance; slash handling a problem; requires 100′ diameter landing + 50′ × 100′ setdown maintenance area

[a] Diameter at breast height.

SOURCE: J. J. Garland, *Timber Harvesting Options*, Extension Service Circular 858 (Corvallis, Oreg.: Oregon State University, 1980).

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[31] See J. J. Garland, *Timber Harvesting Options*, Oregon State University, Extension Service Extension Circular 858 (Corvallis, Oreg.: Oregon State University, 1980), for a discussion.

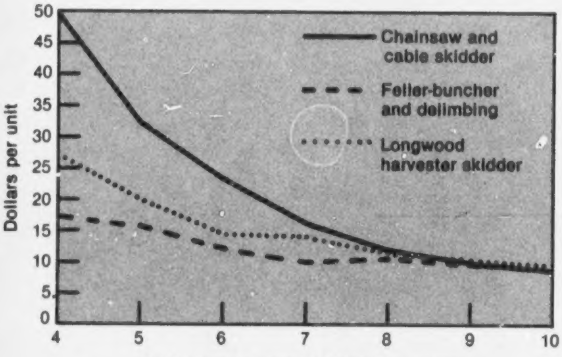
and nonindustrial forestlands are harvested by ground-based methods. Costs may range from a low of $15 per thousand board ft of timber logged with skidders in favorable operating conditions to a high of over $200 per thousand board ft logged with helicopters.

Costs increase rapidly as tree size declines (fig. 20). Workers must handle more pieces to produce the same volume of wood, so that as tree size declines from 10 to 4 inches in diameter at breast height (4.5 ft above ground), costs increase by 70 to 80 percent.[32] Tract size also affects harvesting expenses because of the fixed cost of moving equipment. One researcher, using simulation techniques to estimate the effect of tract size on harvest cost, found that highly mechanized equipment presently available becomes inefficient as tracts drop below 100 acres.[33] This has significant implications for the future as more wood is obtained from small private nonindustrial tracts.

The skill of equipment operators and other crew members also is critical in determining production costs. As in any industrial enterprise, production rates can vary from 65 to 135 percent of normal depending on worker expertise and work habits.

Aerial equipment, while more costly, is better suited to steep terrain than is ground-based equipment. In the West, aerial equipment is commonly used on slopes greater than 35 percent. Regulations for State forest practices in Oregon, Washington, and California, for instance, require its use on steep slopes. Within the last 5 years, a few small U.S. manufacturers have placed light, highly mobile and inexpensive cable machines on the market that may be

Figure 20.—Cost Comparison for Cutting and Skidding by Diameter Breast Height for Three Logging Systems



SOURCE: Adapted from J.R. Erickson, "Changing Resource Quality: Its Impact in Harvesting and Transporation," in *Impacts of the Changing Quality of Timber Resources*, Forest Products Research Society Proceedings No. P-78-21, 1978.

Photo credit: U.S. Forest Service

Helicopter yarding of logs is expensive, but can open up areas to logging that are too inaccessible or environmentally sensitive for ground-based yarding systems useful for harvesting small timber in private nonindustrial forests in steep areas.

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[32] J. R. Erickson, "Changing Resource Quality: Its Impact in Harvesting and Transportation," in *Impacts of the Changing Quality of Timber Resources,* Forest Products Research Society, Proceedings No. P-78-21, 1978.

[33] F. W. Cubbage, "Economies of Forest Tract Size in Southern Pine Harvesting," unpublished paper on file at the U.S. Department of Agriculture, Southern Forest Experiment Station, 1982.

The structure of the logging industry also is an important consideration affecting the current and prospective design of harvesting systems. Some forest products firms maintain their own logging crews, but independent contract loggers are responsible for a large portion of U.S. harvesting operations. Most such logging operations are small in scale. In 1977, there were over 15,000 independent logging establishments, employing about 83,000 workers, an average of less than 6 employees per firm. This figure does not include crews hired by sawmills and pulpmills, farmers or part-time loggers. According to a 1982 report on Canadian companies' equipment marketing prospects in the Southeast, forest products firms have largely disbanded their logging crews in the region except for areas or conditions where specialized machines are called for.[34] The small-scale nature of southern logging contractors, averaging about $250,000 invested in equipment, is a key determinant of equipment needs.

Harvesting Machinery

Priorities for new developments in harvesting machinery differ by region. To fully utilize available forest resources in the East, harvesting machines need to be highly mobile, with low environmental impact, and able to harvest, handle, and process large numbers of small irregular pieces. Prospects for companies that develop such machines appear favorable, according to a recent Canadian assessment of the potential for Canadian firms to penetrate U.S. equipment markets (see box B).

In the West, including Alaska, harvesting systems for steep terrain are needed that produce little environmental impact and that can economically deliver timber from thinnings and wood residue to roadside. Other systems capable of reaching long distances could provide access to some presently inaccessible areas.

A systems approach to developing machines for growing, managing, and harvesting trees of given specifications for delivery to processing centers[35] has not yet been undertaken in the United States. Most big manufacturers produce machinery primarily for agricultural or construction markets and only secondarily for harvesting timber. Much of the harvesting equipment now available is simply modified agricultural or construction vehicles. In addition, small, independent contract loggers, who play a major role in harvesting even in the Pacific Northwest where there are large consolidated tracts of industrial land, are not organized in a fashion that leads to the communication of desired specification for harvesting systems to machinery designers.

Harvest Methods

Harvesting machinery must be used properly if it is to be economically and environmentally acceptable. In many cases, machinery currently available can be more effective if new methods for its operation are devised. For example, small, low-cost skyline yarders designed for harvesting timber within 300 ft of roads can be used to reach timber 1,000 ft from roads using a method called "multispan logging." This system, designed in Western Europe, extends the reach of small yarders by suspending the cable from supports hung between two trees and operates much like a ski lift. In many regions, this method could provide access to timber too small to be yarded by large expensive systems with long-reach capabilities or to environmentally sensitive terrain where few logging roads can be used.

Soil disturbance has become a major environmental concern in many forests. Tractors have been prohibited from harvesting timber on sensitive soils on some Federal lands because of the potential for site damage from normal tractor operations. Harvesting by cable

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[34] Department of Canadian External Affairs, *Market Studies of United States: Canadian Forestry Machinery and Equipment in the Southeastern United States,* prepared by Sandwell International, Inc. (Ottawa, Canada: Canadian Department of External Affairs, August 1982), p. 12.

[35] See "Developing Harvesting Systems for the Future," op. cit., for a discussion.

Box B.—Harvesting Technology in Western Europe

The development of harvesting machinery in Western Europe began in much the same way as it did in the United States. Most equipment was fabricated by individuals or small shops. In the last 15 years, however, Western European manufacturers have begun to design more complete systems for harvesting, preprocessing, and transporting wood from stump to mill. Scandinavian countries have led this transition from a machine to system focus. These countries were forced to better integrate harvesting with tree growing and processing because of increasing labor costs and a growing proportion of their timber supplies taken from small, nonindustrial private forestlands—factors that also affect the forest products industry in the United States. In Sweden, where there are some 247,000 small forest owners, 56 percent of the forestland tracts are less than 62 acres in size. In Austria, over 80 percent of the forest is privately owned and nearly all is in tracts of less than 500 acres.[36]

Rapidly rising labor costs threatened to price Swedish wood products out of the world market in the early 1960's. Reducing those costs became a national objective and the government, organized labor, forest owners, and machinery manufacturers banded together to form a cooperative research organization whose main charge was mechanization of timber harvesting. In 20 years, harvesting in Sweden was transformed from a high-cost, labor-intensive operation to a low-cost, mechanized activity.[37]

The payoff from such R&D can be very high. In Sweden, productivity was roughly 46 ft^3 per worker-day in 1950. By 1975, it had increased about 7.5 times to 350 ft^3 per day. The net result of improved productivity was that Sweden remained a competitor in world markets. Its present research thrust is the development of highly mobile, low-cost machines for use on small, scattered, nonindustrial forests.

The importance of small, privately held forests has led Western European manufacturers to produce a wide variety of small, inexpensive, highly mobile machines that can be used individually or as part of an integrated system. Such machines make it easy for landowners to harvest their own timber and encourage them to manage their forests as part of their agricultural enterprise. Many machines are designed to operate from the power takeoff of common farm tractors.

Data is not available to assess the role that development of harvesting machinery for private nonindustrial owners has played in increasing supplies of wood to Western European mills. It is likely, however, to be significant, especially in Scandinavia. Sweden, for example, relies on nonindustrial forests for about 70 percent of its wood. Forest products continue to be the nation's leading export commodity, evidence that output from nonindustrial lands remains high and that small private owners continue to contribute to the country's wood supply.

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[36] Western European landownership trends are discussed in Swedish Institute, *Forestry in Sweden* (Stockholm, Sweden: Swedish Institute, 1979); and G. W. Brown, "INTERFOREST 82—Technology and Science of Managing Small, Young Forests," *Journal of Forestry*, vol. 80, 1982, pp. 702-703.

[37] G. W. Brown "Harvesting Research and Development in Sweden," *Journal of Forestry*, vol. 80, 1982, pp. 793-794, 800.

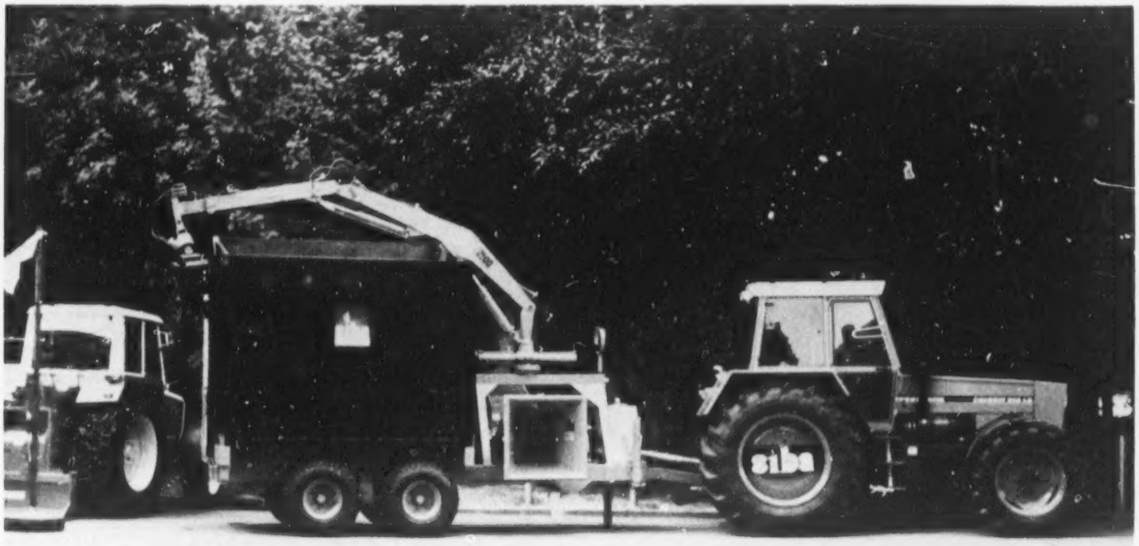

Photo credit: George Brown

Development of small harvesting equipment for use on private nonindustrial forestland has been a priority in Western Europe and Scandinavia. The photo shows a tractor-powered chipper and detachable chip bin

systems is permitted, but costs over twice as much. As a result, much of the timber effectively is excluded from harvest because it cannot be extracted economically. Recent research on new methods of harvesting within acceptable levels of soil disturbance and cost may change this situation.[38]

Transportation Systems

Once harvested, timber must be transported from the forest to processing centers. For processing centers that convert wood to fiber or composition products, a broader array of options is available to transport wood besides the standard log common today. These options include whole trees, tree-length logs, chips, chunks, and compacted bales of residue. An advantage of using chunks or compacted bales, for instance, is that more wood fiber can be packed into a load than with logs, especially if they are crooked and limby. Transportation costs thereby are reduced and more timber can be harvested economically.

Broader transportation questions are raised with the development of new harvesting systems. These questions include the adequacy of existing highways and the design of vehicles capable of dealing with diverse conditions. For example, most forest roads are designed for log trucks that bend in the middle. Vans to haul chips or chunks are designed primarily for highway use and have a different configuration. This means they can neither turn around nor negotiate curves on standard logging roads as easily as most logging trucks. In some cases, bridges and overpasses limit the size of trucks to be used and would need to be redesigned or strengthened to accommodate heavier loads or wider carriers. Highway problems and likely solutions differ by region. The West has long haul distances on secondary or low-volume gravel roads; the East has a more extensively developed, paved public road network where load limits and aging bridges are disadvantages.

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[38] As discussed in H. A. Froehlich, D. E. Aulerich, and R. Curtis, *Designing Skid Trail Systems to Reduce Soil Impacts from Tractive Logging Machines,* Forest Research Laboratory Research Paper 44 (Corvallis, Oreg.: Oregon State University, 1981).

Training for Woodsworkers

New machines and new methods require trained crews to use them. As machines become more sophisticated, they usually become more expensive; abusive treatment or inefficient operation can affect costs significantly. Unfortunately, woodsworker training has been given low priority in North America. In Scandinavia, operator training has received equal emphasis with machine development because researchers and managers recognize that the two are closely linked (see box C). Probably half of the increased productivity experienced in Sweden can be attributed to operator training programs. In central Europe, productivity for a well-trained crew averaged 19.3 minutes per cubic meter harvested; an untrained crew required 43.5 minutes.[39] If similar gains in productivity can be achieved in the United States, timber now considered too costly to harvest could be added to the supply base.

Woodsworker training could improve the logging industry's safety record and reduce harvesting costs associated with workers' compensation payments (table 20). Among industries in 1976, logging had the second highest injury and illness rate and thus had high compensation rates. Logging is already a dangerous occupation but may become more so as workers are required to handle more pieces and as operations move into more difficult terrain.

Table 20.—Summary of Workers' Compensation Insurance Rates by State for Logging and Lumbering Workers (cost per $100 of payroll)

State	1974	1978	1980
Alabama	$9.37	$10.52	$12.52
Arkansas	15.26	18.26	22.00
Florida	13.60	32.59	27.69
Georgia	13.52	16.10	22.16
Louisiana	29.90	39.68	52.10
Mississippi	23.24	34.59	44.36
North Carolina	10.47	16.54	28.59
Oklahoma	26.34	32.26	53.35
South Carolina	9.23	16.03	22.29
Tennessee	14.08	19.61	17.43
Texas[a]	27.06	41.90	14.98
Virginia	8.86	15.37	23.69

[a] Texas rates were lowered in 1980 to encourage employment.

SOURCE: *Market Studies of the United States: Canadian Forestry Machinery and Equipment in the Southeastern United States* (Ottawa. Canadian Department of External Affairs, 1982), p. 12.

Workers' compensation rates paid by employees for their crews are very high, and contribute significantly to the costs of logging. Injuries and associated costs may continue to rise unless training programs can improve the safety record.

Training workers also could reduce environmental impacts of harvesting and improve timber management. Since most PNIF lands are not harvested under a management plan prepared by a professional forester, special woodsworker education could be directed at owners of private nonindustrial forests. Some owners personally harvest their own timber, a choice common in Europe and among some U.S. farmers. In other cases, owners who do not perform the harvest themselves may benefit from learning more about harvesting timber and be better prepared to make decisions about harvest programs. Such education may be an important key to the availability of timber on private nonindustrial forestlands.

Research and Technology Transfer

If timber supplies are to increase from improved harvesting and land management technologies, additional improvements may be needed in the present system of forestry-related research and technology transfer. The United States does not have a research organization like the Forest Engineering Research Institute

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[39] A. Trzesniowski, *Logging in the Mountains of Central Europe* (Rome, Italy: United Nations FAO, 1976).

Box C.—Marketing Canadian Equipment in the Southeastern United States

Development of small, multipurpose harvesting equipment for use on nonindustrial tracts could aid in increasing timber supplies from PNIF lands. Such equipment is widely available in Scandinavia and Western Europe, where small tract ownerships are common, but less so in the United States. Sensing an opportunity for Canadian manufacturers, the Canadian Government recently undertook a study of the potential market for Canadian-manufactured harvesting equipment in the Southeastern United States.[40]

The Sandwell International study, commissioned by the Canadian Department of External Affairs, found "no reasons . . why Canadian-manufactured forestry machines and equipment could not obtain an increased market share in the Southeastern United States." Although some import duties could affect Canadian competitiveness, favorable exchange rates between Canadian and U.S. currency would probably balance duties.

From interviews with logging contractors and corporate executives, the study concluded that "existing equipment design will not meet future requirements for log harvesting." More intensive silviculture with associated commercial and precommercial thinning will establish a need for smaller, highly mobile skidders and harvesting equipment able to be used for several purposes. Machines designed to meet noise reduction standards, reduce damage to plants, and minimize stream water pollution would also be desirable.

The potential for Canadian penetration of the skidder market was found to be especially high, due to a continuing need for replacements (2,500 to 3,500 per year in the United States). Attachment devices able to run off tractors also were given high potential, due to unique designs by some Canadian manufacturers. Reforestation equipment was also found to be a promising market if Canadian manufacturers adapted their designs to Southeastern U.S. environmental and topographic conditions.

The study also assessed marketing strategies. Because many forest products firms have cut back their own logging operations, the most successful strategy, according to the study, would be aimed at independent contractors, followed by farmers and other part-time loggers with a need for attachments running off farm equipment. Dealerships were found to be crucial for successful marketing, since few loggers were willing to travel more than 30 miles for services. Trade fairs were found to be less effective because loggers want to see equipment in actual operation. Therefore, demonstrations at harvest sites by forestry schools and State agencies were thought to be more promising. In addition, cooperative efforts with vocational schools would help train woodsworkers to use the new machinery and facilitate market penetration by giving operators a chance to test equipment.

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[40] Canadian Department of External Affairs, *Market Studies*.

of Canada, which carries out coordinated research on harvesting. Furthermore, public resources currently directed to harvesting systems research are quite small. In 1976, only 70 scientist-years of effort were devoted to it, and it comprised less than 2 percent of the Forest Service research budget.[41] Greater emphasis on R&D may be needed if harvesting systems that extend timber supplies are to be forthcoming.

Traditionally, the formal framework for forestry-related technology and information transfer has been weak in the United States. This situation may improve over time, however, if the Renewable Resources Extension Act of 1978 (Public Law 95-306) bringing forestry more fully into the agricultural extension system, is adequately implemented.

The 1978 act gives forestry a greater priority in the Cooperative Extension System, which for nearly 70 years has served as a vehicle to help farmers in on-the-ground application of agricultural research findings. The act called for periodic development of a National Renewable Resources Extension Plan, along with complementing State plans, to identify renewable resource priorities in the extension system. The initial program was submitted to Congress in 1980. Earmarked funding for renewable resources extension was not provided until fiscal year 1982, and it has been proposed for deletion in fiscal year 1984. As a result, most forestry-related work is conducted with discretionary funds allocated chiefly to agricultural activities (see box D).

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[41] C. W. Boyd, W. W. Carson, and J. E. Jorgensen, "Harvesting the Forest Resource—Are We Prepared?" *Journal of Forestry*, vol. 75, 1977, pp. 401-403.

Box D.—Forestry in the Cooperative Extension System

The National Cooperative Extension System is the primary means by which government speeds agricultural research findings on technology and management to landowners and other members of the public. Established in 1914 by the so-called Smith Lever Act, the system is comprised of USDA, land-grant universities, and State and county government extension agencies. Nearly all of the over 3,000 counties in the United States have extension offices which conduct information, education, and demonstration programs related to activities as diverse as forestry, home economics, marketing, and agricultural production.

Federal cost-sharing of forestry-related extension activities has occurred at a modest level for many years ($1.6 million in 1979) under general-purpose appropriations or separate appropriations for specific projects. Most of these activities are aimed at encouraging land management by private nonindustrial owners, although wood utilization activities also have been authorized. Federal funds account for 30 percent of project costs. A State's cost-share is 70 percent. Extension forestry activities typically are undertaken in conjunction with other agencies, including the Forest Service, State forestry offices, the Soil Conservation Service, local conservation districts, and county agricultural conservation program committees.

Examples of cooperative extension forestry-related activities include:

- provision of stumpage price information in some county extension offices in the South,
- operation of metropolitan area workshops on timber management investment opportunities for absentee forestland owners,
- initiation of a Northeastern project for improving timber stand management through income-producing fuelwood thinning, and
- establishment of County Forest Resources Associations in several States.

An organizational framework for increased involvement of the extension system in forestry was provided by the Renewable Resources Extension Act of 1978. The act called for development of a National Renewable Resources Extension Plan on a 5-year basis.

In the initial renewable resources extension plan submitted to Congress in 1980, States identified educational and informational "opportunities" associated with extension forestry which would require 493 staff-years to implement. This compared with 160 staff-years of forestry extension activities in 1980.

Although the 1978 act specifically authorized earmarked Federal appropriations, up to $15 million annually, for renewable resource extension purposes, Federal funding continues at a modest level. Actual funding ($2 million) was not provided until fiscal year 1982 and has been proposed for deletion in the fiscal year 1984 budget request. Smith Lever general funding thus may continue to be the primary source of forestry funds, with forestry competing with other activities for Federal support.

At present, however, fewer than 10 people are actively involved in formal harvesting extension programs, and all forestry-related extension activities entail only about 160 staff-years or effort annually. If the increased productivity witnessed in agriculture that is attributable to extension education could be duplicated for forest resources, the timber supply would likely be markedly improved.

Increasing Timber Supplies Through the Manufacture and End Use of Wood Products[42]

More efficient use of wood in the manufacture of forest products could be achieved in several ways by:

- the expanded use of underutilized tree species, wood residues, and defective materials that are now left in the woods after harvest;
- the increased recovery of high-value primary products, such as lumber and plywood, from roundwood logs;
- the increased use of manufacturing residues for particleboard and fiberboard;
- increased efficiency in end use of wood products, such as in the design of houses; and
- increased recycling of paper.

A variety of products can be made from underutilized trees. Such products may substitute increasingly for wood products derived from more costly and scarce raw materials. Application of advanced engineering techniques to end uses of wood, such as in design and construction, also could improve efficiency by economizing on the use of the resource while maintaining structural quality.

There are additional opportunities to improve raw material use in the mill. In 1976, over 96 percent of the wood entering mills for primary processing was either converted into wood products, such as lumber, veneer, plywood, composite panels, and pulp and paper, or burned to supply the energy needs of the industry. Although most material is used, product yields can be improved as new mills, able to process wood more effectively, come on line.

Technological Adjustments to Changes in Growing Stock

Historically, the U.S. forest products industry has adapted well to changes in species availability and growing stock.[43] As preferred species, sizes, and qualities of wood have become depleted due to increased demand, processing technologies have been adjusted to work with more abundant species and materials previously thought to be unusable.

There are several examples of the industry's accommodation to raw materials availability. Originally, the pulp and paper sector depended on northern spruce and fir for papermaking. As inventories of spruce and fir declined in the early 1900's, widespread concern arose over possible shortages, since other species such as southern pine were thought to be unsuited for paper. However, the sector, aided by research laboratories, quickly adapted the kraft sulfate papermaking process to southern pine, which now is a major contributor to paper production.[44] In addition, research was initiated on the use of lesser quality hardwoods in paper, so that suitable low-grade hardwoods are now added to the raw materials mix.

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[42] See volume II of this report for detailed discussion of wood utilization and manufacturing technologies from which this section is derived.

[43] See, for example, Egon Glesinger, *The Coming Age of Wood* (New York: Simon & Schuster, 1949), in passing, for discussion of changes in raw materials utilization by the forest products industry.

[44] As discussed in Ibid., pp. 169-172.

Similarly, plywood producers initially depended on large-diameter, straight western softwood. As a result of increasing prices for such timber and uncertainties about future supplies, manufacturers learned to use previously untried southern pine in the early 1960's. By 1980, the South produced nearly as much plywood as the West, generally using smaller logs.

Implications of New Wood Products for Fuller Use of Resources

Today, softwoods are preferred for lumber, plywood, and certain papers. As currently preferred softwood grades become scarcer and more expensive, the forest products industry continues to seek ways to use different portions of the timber resource through the expanded utilization of hardwood species and the expanded recovery of wood left in the forest after "merchantable" material is removed.

Hardwood species present major opportunities for greater use. Hardwood inventories, found mostly in the East, comprise more than one-third of the Nation's growing stock and are multiplying fast. In 1976, hardwoods accounted for 36 percent of the standing timber, but only 26 percent of roundwood supplies.[45] Existing and emerging technologies can produce materials from hardwoods of similar performance to many products now produced mainly from softwoods.

In the pulp and paper sector, the increased substitution of abundant hardwoods in the production of papers suitable for a variety of uses could relieve resource problems caused by the economic scarcity of softwoods. While several technologies could permit greater hardwood utilization, only about one-fourth of the pulpwood used in the United States presently is derived from hardwoods.

Current pulping processes can use a broad range of woody materials, such as wood residues and chips. Over 35 percent of the total wood used for kraft paper comes from residues. In the Pacific Northwest, nearly 90 percent of the wood used for pulp originates from sawmill or veneer mill residues.[46] The suitability of whole tree chips, including bark and branches, is now under study; when efficient segregation methods are developed, these chips could greatly enlarge the wood resource available for pulp products. In addition, waste paper now accounts for about one-fourth of the fiber used in the industry; increased recycling is also feasible (see box E).

The lumber and panel sector has adjusted its processes to use smaller logs, as second-growth timber replaced old-growth and as tree utilization standards changed. This trend will probably continue. The potential of hardwoods in structural plywood production is being explored. Some studies have concluded that construction-grade hardwood plywood made from a mixture of high- and low-density species could be economically competitive with softwood construction plywood.[47] Improved methods of drying and seasoning hardwoods[48] could provide additional impetus for their use in plywood.

Several composite panel products have been developed for structural application, including waferboard, oriented strand board, and Com-Ply in which a particle core is overlaid with a veneer surface. Nearly all the new panel products developed in the last 30 years can use hardwoods and some wood defective for other uses, thus extending the timber resource.

Waferboard and flakeboard panels (made of wood wafers or large flat flakes) can be made from any hardwood species, but the less dense species are best. Waferboard is unsuitable for some structural applications but may substitute for plywood for sheathing. Waferboard has

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[45] Derived from *An Analysis of the Timber Situation*, op. cit., 1982, p. 158.

[46] D. A. Tillman, A. J. Rossi, and S. O. Simmons, *Wood: Its Present and Potential Uses* (OTA contract report prepared by the Envirosphere Co., April 1982), p. 4-25.

[47] R. W. Jokerst and J. F. Lutz, "Oak-Cottonwoood Plywood: No Delamination After Five Years," *Plywood and Panel Magazine*, June 1981, p. 18.

[48] See Walter R. Smith, "New Horizons in Hardwood Utilization," manuscript presented at Forest Products Utilization Research Conference, Forest Products Laboratory, Madison, Wis., Oct. 19-21, 1982, pp. 8-9 for a discussion of hardwood seasoning research.

Box E.—Potential for Increased Recycling of Waste Paper

About 23 percent of the fiber used by U.S. papermakers in 1980 came from waste paper according to a recent report prepared for the Solid Waste Council of the Paper Industry.[49] Paper recycling declined in the 1950's and most of the 1960's, but has been increasing since 1968.

Most waste paper is not recycled. In 1980, 67.8 million tons of paper were consumed and about 42.7 million tons of paper were disposed of in landfills or were otherwise not recovered. An estimated 6.2 million tons were diverted, destroyed, or lost in use and therefore were not recoverable for recycling, and 0.8 million tons were burned to produce energy. About 18.1 million tons were recovered for recycling, up from 12.9 million tons in 1971.

A portion of the paper recovered for reuse—2.7 million tons—was exported. The remaining 15.4 million tons were used as raw material in the production of new domestic paper.

Of the 18.1 million tons of paper recovered for recycling, 8 million tons consisted of corrugated paper (i.e., box plant cuttings and corrugated containers) obtained primarily from commercial enterprises. The balance consisted of a mix of paper types, the most important of which was newsprint obtained chiefly from residential users.

Collection of waste paper is difficult, especially outside of urban centers. Furthermore, waste paper is not always easily separated from nonfiber contaminants. Eliminating contaminants is often laborious and inconvenient and is frequently not fully accomplished. Contaminant problems arise in part from lack of coordination among the industries making, using, and recycling paper. Cooperation among them could be beneficial and could greatly reduce obstacles to recycling. If paper converters used water soluble inks and glues, for example, subsequent recycling would be easier.

Municipal burning of waste paper for energy has been singled out by the paper manufacturers as potentially competitive. According to industry estimates, waste paper burned for energy production could increase from less than a million tons in 1980 to nearly 9 million tons in 2000. For this reason, the industry is concerned that municipal efforts to address solid waste disposal problems through waste-to-energy systems could create supply problems for paper recyclers.

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[49] Franklin Associates, Ltd., *Waste Paper: The Future of a Resource 1980-2000*, report to the Solid Waste Council of the Paper Industry (New York: American Paper Institute, 1982).

been widely accepted in Canada where it was first introduced. Several waferboard plants now operate in the United States, most of which are in the Great Lakes States and New England.[50]

Product Recovery in the Solid Wood Products Sector

From roundwood, the solid wood products sector produces a variety of goods, including dimension lumber, plywood, laminated lumber, molding, and furniture stock. Leftover materials generally are shipped to pulpmills and particleboard plants or turned into other composite materials. Remaining materials, such as bark and sawdust, are burned as fuel, so virtually all of the roundwood—more than 95 percent—is used in some way.

Improving Yields in Lumber Manufacture

Lumber products include dimension lumber, boards, finish lumber, and timbers. Of all lumber and panel products produced in the United States in 1979, almost 70 percent (by weight) was lumber.[51] Available technologies

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[50] Initial waferboard plants were established in the Great Lake States; subsequently, several others were established in New England. Trends are discussed in Lloyd C. Irland, *Wildlands and Woodlots: The Story of New England Forests* (Hanover and London: University Press of New England, 1982), p. 160; and Henry M. Montrey, III, *Current Status and Future of Structural Panels in the Wood Products Industry*, M.S. thesis, Massachusetts Institute of Technology, June 1982, pp. 110-115.

[51] U.S. Department of Agriculture, Forest Service, *U.S. Timber Production, Trade, Consumption, and Price Statistics, 1950-1980*, miscellaneous publication No. 1408 (Washington, D.C.: U.S. Government Printing Office, 1981), p. 10.

Photo credit: U.S. Forest Service

A variety of solid wood products are now used, but lumber continues to be the largest use by weight

could increase lumber yields per unit of roundwood, but these technologies would reduce the wood left over for nonlumber wood products.

About 40 percent of a log entering a typical sawmill is converted into dimension lumber. Most of the rest becomes sawdust, shavings, and edging used to manufacture particleboard, fiberboard, and paper or is used for fuel. With new technologies and processes, lumber recovery in mills could reach between 60 and 88 percent for medium-sized logs.[52] Material tradeoffs are important, however, in balancing lumber recovery efficiency with the production of other goods and energy.

Several processes could increase lumber recovery without major sawmill modifications:

- The **best opening face process** produces higher grades and increases recovery of lumber through computer-assisted selection of sawlines during milling. Laboratory tests indicate that this process could increase lumber yields by 20 percent and some in-service tests have confirmed this.
- The **saw-dry-rip process** enables fuller use of hardwoods by reducing their tendency to warp and deform and also permits use

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[52] Jerome Saeman, "Solving Resource and Environment Problems by More Efficient Utilization of Timber," in *The Report of the President's Advisory Panel on Timber and the Environment* (Washington, D.C.: U.S. Government Printing Office, April 1973), app. F, p. 361.

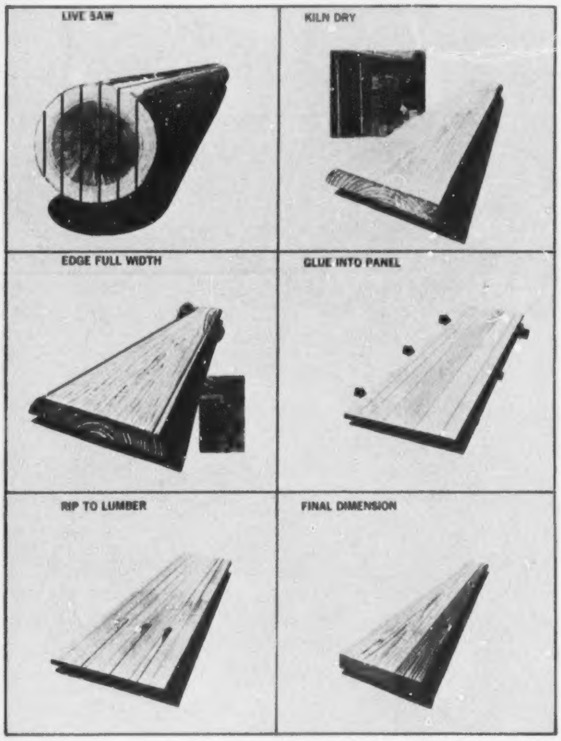

Photo credit: U.S. Forest Service

The Saw-Dry-Rip process enables fuller utilization of logs, particularly hardwoods

of defective timber and wood residues that were once considered unmerchantable.

- The **edge-glue and rip process** is an innovative sawing and gluing technique which reduces wood loss and permits use of low-quality raw materials to produce high-quality lumber-like products.

Other available processes could improve product recovery, but would require costly investment by mill owners. Technologies for composite products, such as Parallel-Laminated Veneer (PLV) and Com-Ply, can produce high-quality, lumber-like products from low-quality materials and hardwoods. The dimensions of PLV and Com-Ply products are not limited by log size and can produce stronger lumber than conventional manufacturing.

Despite the advantages, the substitution of composites for dimension lumber may proceed slowly. Composite lumber manufacture requires expensive equipment, which therefore is more likely to be installed in new mills than retrofitted in old ones. As existing sawmills are depreciated, PLV facilities may be built as replacements, particularly if stumpage values increase and building codes are modified to permit the use of PLV lumber.

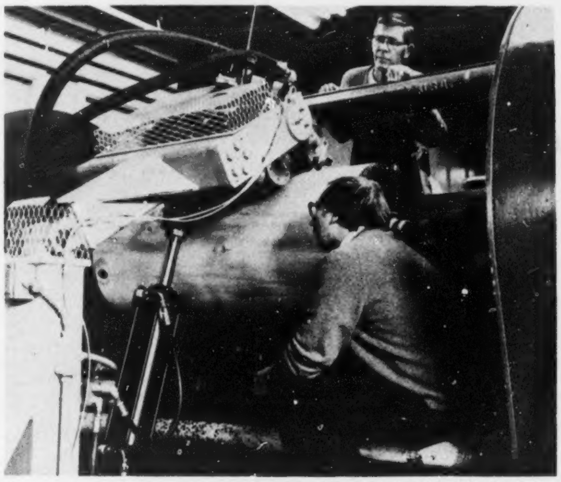

Photo credit: U.S. Forest Service

The power backup roller can improve veneer log yields in plywood manufacture

Potential Improvements in Plywood Manufacture

At present, plywood recovery runs between 47 and 53 percent.[53] Less than 1 percent of all roundwood used in plywood manufacture is waste, because residues from plywood mills are used for lumber, particleboard, pulp, paper, fiberboard, and fuel.

Mills now accept smaller logs than in the past, and there is an increasing effort to use hardwood for structural plywood. Many innovations in structural panel manufacturing have focused on expanded use of hardwoods and lower grade wood.

Currently, 25 percent of the veneer logs brought in from the forests are considered unsuitable for peeling.[54] Because of the high value of veneer logs, reducing the amount of unusable material can improve the productivity and profitability of the mill, and some promising technologies for accomplishing this have been developed.

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[53] Kidder, Peabody & Co., Inc., *A Critical Issue Report: Com-Ply Waferboard, Oriented Strand Board: Revolution in the Structural Panel Market* (Kidder, Peabody & Co., Dec. 24, 1980), p. 14.

[54] Frank J. Fronczek, "Preventing Veneer Bolt Spinout," reprinted from *Modern Plywood Techniques*, proceedings of the Seventh Plywood Clinic, Portland, Oreg., 1979, p. 22.

Product Recovery by the Pulp and Paper Sector

The increased cost of energy, the rising cost of both roundwood and sawmill residues, market emphasis on printability and other nonstrength factors, and the abundance of less expensive hardwood timber have all prompted the pulp and paper sector to consider more energy-efficient and materials-efficient manufacturing technologies. Now pulp and paper manufacturers are turning out higher quality pulps that require less wood per ton of pulp produced.

In 1978, the pulp and paper sector consumed approximately 77 million short tons of ovendry pulpwood. Forty-four percent came from chips and sawmill residues. About 26 percent was hardwood. Trends in wood use in the past 40 years have moved toward the increased utilization of hardwood species and increased reliance on chips and sawmill residues. In addition to mill residues and chips, pulp and paper manufacturers used approximately 15 million short tons of recycled waste paper for pulp and paper production.[55]

Photo credit: U.S. Forest Service

Modern papermills can achieve fuller wood utilization and decreased requirements for purchased energy

More widespread adoption of mechanical pulping technologies could further reduce fiber requirements. For example, it takes an estimated 2.5 short tons of wood to produce 1 ton of paper through the kraft chemical pulping process. Only 1.05 short tons of wood is required to produce 1 ton of paper in thermomechanical pulping. With this potential reduction, each 2-percent increase in pulping capacity would require only a 1.7-percent increase in wood fiber.[56]

While incremental improvements in current processes may be important in raising the efficiency of existing mills, the greatest potential for dramatic advances in pulp and paper manufacture lies in new technologies. Such innovations could enable the use of large quantities of currently underutilized hardwood species and may even present prospects for developing superior new papers for specialized needs. At the same time, new concepts in energy use and cogeneration could achieve new levels of energy efficiency, thus freeing up additional fiber for paper.

Press-drying technology, developed at the U.S. Forest Products Laboratory, holds promise both for reducing the amount of energy required in papermaking and for enabling the use of dense hardwood species, such as sweetgum and red oak, which are not currently used in large quantities for pulp. Press-drying uses high-yield hardwood or softwood kraft pulp to produce linerboard with strength superior to conventional softwood kraft paper in every respect except tear strength. At the same time, press-drying can reduce the amount of energy needed in the drying process by applying pressure to the fiber (pulp) mat as it is dried, in contrast to conventional drying that applies pressure and heat separately.

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[55] Joan E. Huber, *The Kline Guide to the Paper Industry* (Fairfield, N.J.: Charles H. Kline & Co., 1980), pp. 66-67.

[56] G. Styon, "Impact of North American Timber Supply on Innovations in Paper Technology," *Paper Trade Journal*, May 30, 1980, p. 28.

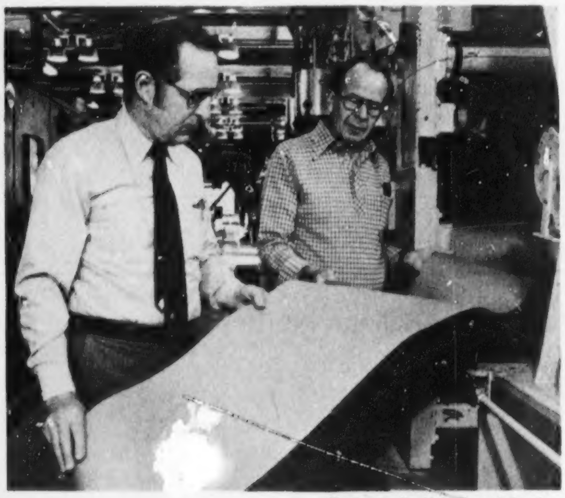

Photo credit: U.S. Forest Service

USDA Forest Products Laboratory scientists have developed a prototype press-dried paper technology

Paper produced from press-drying kraft red oak pulp has been shown to have a burst and tensile strength approximately 13 percent greater than conventionally dried pine kraft paper. Compression strength of the press-dried red oak paper was 50 percent better than the pine. The lower tear strength of press-dried hardwood paper may limit its use for wrapping or sack paper; however, its higher burst and tensile strength make it suitable for linerboard.

An estimated 19 percent in net energy savings could be gained from the use of press-drying technology.[57] Press-drying also may reduce equipment requirements in both the drying section and the pulping process because of its capability for using unrefined pulp although this is uncertain because a commercial-scale press-dry paper machine has not yet been built and operated.[58] The major limitation of press-drying to be overcome before the technology can be used commercially, is the low speed of the Forest Products Laboratory's pilot-scale paper machine and the resulting slow production rate.

Decreasing Energy Requirements

The forest products industry now burns about half the wood entering its mills to meet internal energy needs. Generally, only low-value wastes and residues are used for fuel, but some residues now used for fuel could be utilized instead in the manufacture of products. Development of energy-efficient wood processing systems could improve the balance between wood energy and fiber recovery.

The major long-term opportunities for energy savings are in the energy-intensive pulp and paper sector. Pulp and paper producers consume about 7 percent of U.S. industrial energy and about 3 percent of the total energy consumed nationwide.[59] About half of the sector's energy requirements currently are met internally by burning wood residues, pulping liquors, and other waste products.

In the near term, the best prospects for reducing the pulp and paper sector's energy requirements may be through increasing the use of mechanical pulping, which uses less energy than chemical pulping methods and recovers a higher proportion of the fiber. Another way may be through expanding the use of recycled paper.

Over the long term, commercialization of some experimental pulping technologies, could help the industry reduce energy needs. One experimental process, an organic solvent extraction process called Organosolv, may permit the industry to become a net energy producer in the future. The Organosolv process also may be capable of using hardwood species and obtaining high fiber yields with little sacrifice in product strength. The process is still in the developmental stage, but it may be commercially available in 25 years or so.

There are also opportunities for the more efficient use of wood fuels in the solid wood products sector. In plywood manufacturing, higher fuel costs have prompted increased interest in the improvement of veneer drying, recycling waste heat, and heat conservation. Use of mill residue, wood dust, and bark for power generation is a common practice in many plywood mills. One manufacturer reports replacement of propane with plywood trimmings and scrap in two dryers at a savings of over 70 percent in fuel costs. Another manufacturer is converting almost all of its wood sanding dust to energy, producing 40 million Btu per hour in auxiliary power.

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[57] V. Setterholm and Peter Ince, "The Press-Drying Concept for Papermaking," *Southern Lumberman*, December 1980.

[58] P. J. Ince, "FPL Press Drying Process: Wood Savings in Linerboard Manufacture," *TAPPI*, vol. 64, 1981, p. 109.

[59] Total U.S. energy consumption in 1981 was 74.1 quadrillion (Quads) Btu of energy.

Veneer drying accounts for 70 percent of the process steam needs of plywood manufacturers. Improved drying processes, aimed at reducing energy consumption and increasing operating speeds, are being developed. One such process, platen drying, increases recovery by 5 to 15 percent, shortens drying time, reduces the need for additional drying, and reduces process steam needs by up to 50 percent.

In lumber production, up to 90 percent of the heat energy consumed in processing is for drying lumber, usually in a steam kiln that circulates air. Kilns may use natural gas or propane directly or, more often, are heated by steam coils. Several new drying technologies, including continuous feed solar, vacuum, and vapor recompression drying, may gain some commercial acceptance by 2000, although none seems likely to completely replace conventional steam kilns.[60]

Increased Efficiency of Wood Products in End Use

Design improvements in construction offer a significant chance to increase efficiency in wood use. Current techniques could reduce substantially the quantity of wood used for home construction, particularly in single-family detached dwellings, without reducing the quality of the structure. Two developments are particularly noteworthy—truss framing and engineered panel assemblies that combine sheathing and framing. The use of trusses is becoming more common for roof and floor systems. Truss framing uses single trusses to frame floors, walls, ceilings, and roofs together. Some analysts estimate that it could achieve as much as 30-percent reduction in lumber use over conventional construction practices. Engineered panel assemblies or stressed-skin panels used for floors, walls or ceilings which combine sheathing and framing in sandwich panels, may also conserve wood. Such assemblies are factory-built, as are trusses, and their use could reduce the wood wastes on construction sites from cutting and custom fitting, while still providing structural strength and stiffness.[61]

Since lumber production is linked closely to the housing industry, an upturn in homebuilding could drive softwood log prices up, thus increasing the incentives for lumber manufacturers to streamline operations and increase product yields to remain competitive. Low rates of residential construction could force many small lumber mills out of business, thus concentrating production in the larger mills that tend to be more efficient. Other developments in the homebuilding industry could also affect the lumber sector, such as moves toward smaller houses and multifamily dwellings.

In the pulp and paper sector, increased paper recycling could reduce demands on the resource base (see box E). Approximately one-fourth of the paper pulp produced each year is from recycled paper, with the practical upper limit for using recycled fiber in the pulp mix increasing as new technologies are developed. The suitability and use of recycled fiber for current paper products varies significantly. Some products (i.e., bleached paperboard) are made with little or no recycled fiber, but in some others one-third or more of the fiber requirement come from recycled materials (table 21). In Europe, paper suitable for many uses is produced from pulp containing as much as 90 percent recycled fiber. However, the potential for further increases in recycled paper use must be weighed against two barriers—the expense of removing glue, ink, and other materials that normally are present in

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[60] Tillman, Rossi, and Simmons, *Wood: Its Present and Potential Uses,* op. cit., p. 3-25.

[61] Trends in wood utilization in construction are discussed in University of Wisconsin Extension, Environmental Awareness Center, *Housing and Wood Products Assessment* (OTA contract report, Dec. 10, 1982).

Table 21.—Utilization of Waste Paper by Sector and Major Grade Category, 1980

Industry/grade category	Total production	Quantity of waste paper used in production	Utilization rate[a]
Paper:			
Newsprint	4,672	898	19.2
Tissue	4,375	1,698	38.8
Other grades	21,144	1,125	5.3
Subtotal	30,191	3,721	12.3
Paperboard:			
Unbleached kraft	15,295	912	6.0
Semichemical	4,724	1,206	25.5
Recycled	7,071	7,710	109.0
Bleached	3,862	2	0
Subtotal	30,952	9,830	31.8
Construction	2,558	1,543	60.3
Grand total	63,701	15,094	23.7

[a] Ratio of the weight of waste paper used in production to the weight of the new paper produced.

SOURCE: Franklin Associates, *Waste Paper, The Future of a Resource 1980-2000* (New York: American Paper Institute, 1982), p. 22.

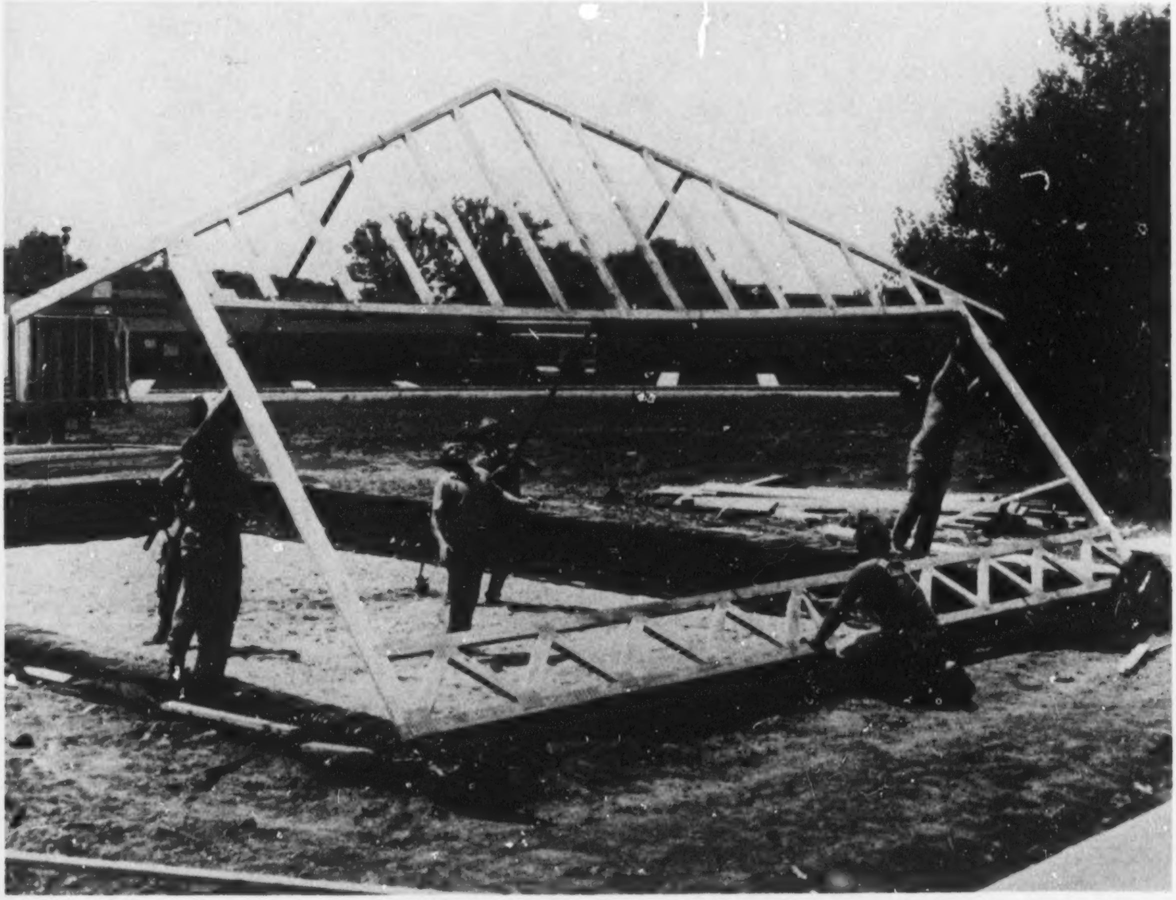

Photo credit: U.S. Forest Service

Truss framing can significantly reduce lumber requirements in light frame construction waste paper and the economics of collection and transportation that limit recycling primarily to metropolitan areas. Recycling reduces the energy requirements of papermaking significantly. It also reduces municipal solid waste disposal problems.[62] [63]

The efficiency of residential and commercial fuelwood burners is another area where significant advances could be made. Approximately one-third of the wood fuel burned in the United States is for home heating.[64] This is about equal to the amount of wood that ends up in paper and paperboard products each year when wood fuel consumption by the forest products industry is subtracted. Firms outside the forest products industry that use fuelwood commercially now constitute a small but very rapidly growing group. The potential for residential/commercial fuelwood demands to conflict with forest industry demands for roundwood may be lessened by more efficient woodstoves, boilers, and furnances.

The number of efficient small capacity burners—stoves in particular—are growing steadily. Many improvements, such as more air-tight designs, have increased burning efficiency by an estimated 1.5 percent annually.[65] Technologies capable of even more efficient wood combustion also may reduce air pollution emissions. One example is wood burning stoves with catalytic converters. As the demand for wood burning devices spreads, further improvements in efficiency, wood handling, and fuel uniformity may follow.

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[62] W. E. Franklin, *Paper Recycling: The Impacts of Contaminants, 1973-1985, Summary and Overview* (Kansas City, Mo.: Midwest Research Institute, 1975).

[63] P. Sizifert, R. Sector, and P. Crirea, "Waste Paper Pulping With Maximum Energy," *TAPPI*, vol. 59, 1981, pp. 111-113.

[64] U.S. Department of Energy, *Estimates of U.S. Wood Energy Consumption From 1949 to 1981* (Washington, D.C.: U.S. Government Printing Office), p. 74.

[65] As cited in Applied Management Sciences, *Methodology for Residential Wood Energy Consumption, Letter Report No. 2: Recommended Methodology* (Silver Spring, Md.: Applied Management Sciences, June 30, 1981).

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CHAPTER VI

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Summary

The U.S. forest resource is quite adequate to meet expected domestic demand for wood products. U.S. forests also could supply expanded international wood markets or unexpected increases in domestic demand if existing technologies for growing, harvesting, and processing wood are widely applied. If demand increases without corresponding adoption of such technologies, however, land resource constraints could arise. These potential constraints include the declining size of the forestland base, private nonindustrial forest ownership patterns, and other uses for forestland that may conflict with industrial wood production.

The U.S. forestland base is declining in size and further reduction is anticipated in the next 50 years, but how much it will decline is uncertain. The Forest Service estimates that 27 million acres of commercial forestland were lost between 1962 and 1977. This drop from 509 million acres to 482 million acres represents a 5-percent reduction over the period. A primary reason for the decline was the conversion of private forestland to agriculture and development. Also, some commercial acreage on Federal land was reclassified as wilderness and is no longer available for timber production. The decline was visible in all regions, but was largest in the South, which lost 12 million acres. By 2030, the Forest Service projects that commercial forests will decline further to 446 million acres, chiefly because the conversion of private nonindustrial land to other uses may continue.

The exact magnitude of the national trend towards a decline in commercial forestland is not certain, because up-to-date field surveys were not available in most States when the Forest Service acreage estimate was made in 1977. While individual State forest surveys are highly reliable, they are only conducted every 12 years on the average. As a result, when the 1977 estimate was compiled, forest surveys in 22 States predated 1970. The Forest Service adjusted some of these surveys, but not on the basis of field data; other pre-1970 surveys were used without adjustment. Consequently, the 1977 composite figure may not fully reflect the diversion of forestland to agriculture and urban uses that took place during the 1970's and may not reflect some shifts back to forestland. Some post-1977 State surveys published by the Forest Service show far higher rates of decline in commercial forestland acreage than listed in 1977, while others show moderate increases.

Divergent estimates of non-Federal forestland by the Forest Service and the Soil Conservation Service (SCS) need to be clarified or resolved if Congress is to receive consistent information in congressionally mandated assessments of land resources. The Forest Service and SCS, both Department of Agriculture (USDA) agencies, collect data on forestland, but SCS efforts are limited to non-Federal lands and do not differentiate between commercial and noncommercial forests. For 1977, the SCS survey showed 74 million acres less non-Federal forestland than the Forest Service estimate and a more rapid rate of decline. The Forest Service figure was reported to Congress in the 1980 assessment required by the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, while an assessment for the parallel Soil and Water Resources Conservation Act (RCA) of 1978 used the SCS figure.

Much of the discrepancy arises from different classifications of forest-range ecosystems that are not of importance to industrial timber supplies. The remainder of the discrepancy is due in part to different procedures, methodologies, and judgments about classification of currently forested land that is in or near built-up areas. In addition, all of the SCS data was collected in the 1975-77 period and may reflect some land use changes not captured by the Forest Service estimates.

The Forest Service and SCS currently are in the process of developing a common non-Federal acreage figure for use in future assessments of renewable resources. Preliminary activities include identifying areas of disagreement between the two agencies on a State-by-State basis. As this report went to press, the agencies' were still developing revised acreage estimates at the national level.

The net effect of an acreage overcount, if it exists, is uncertain. On the one hand, an overcount of forest area could cause an upward bias in estimates of current and projected growing stock volumes. On the other hand, Forest Service estimates about growth rates and management intensity are conservative and consequently may bias the estimates downward (see ch. IV for a discussion of projection methods).

More up-to-date information about forestland acreage and ownership is needed in Forest Service data used for the periodic assessment and program required by RPA. The long interval between State surveys is a major cause of uncertainty about national forestland data. The interval is probably too long to meet the periodic reporting requirements of RPA, and it may explain some of the discrepancy between Forest Service land data and that of the SCS. Recent cooperative initiatives by the Forest Service, other Federal agencies, and State agencies, such as "midcourse" survey updates in key timber-producing States, may help to improve the timeliness of information. More detailed data about forest land ownership, especially in the southern United States, could also improve the information available to decisionmakers.

Rapidly increasing residential use of wood for fuel is a major new influence on the U.S. wood situation, but it is so recent that its precise effects are hard to determine. Home fuelwood use may have both positive and negative ramifications for forest resource management. For example, fuelwood harvesting could complement timber management by removing "weed" trees. If poorly done, however, fuelwood harvesting could conflict with timber management by removing trees that are more valuable for industrial uses. If wood demand continues to grow and prices rise significantly, competition in the roundwood market could intensify between industry and homeowners.

The magnitude of these effects is difficult to analyze. Recent Forest Service and Department of Energy estimates of residential fuelwood use for 1981 are seven to eight times greater than those the Forest Service issued for 1976. Preliminary Forest Service figures indicate that about 27 percent of the residential fuelwood cut by landowners comes from trees that potentially contain sawlogs and pulpwood. It is not known what proportion of purchased fuelwood comes from industrial growing stock.

Predictive capabilities about tradeoffs between timber production, environmental values, and other forest uses need to be improved. Timber production both affects and is affected by rising demand for many other economic, social, and environmental uses and values that forestland provides. Both public and private forests are critically important for recreation, wildlife habitat, watershed management, soil conservation, environmental quality, landscape esthetics, and other purposes. While timber production often is compatible with all of these purposes, and while land management strategies can be designed to achieve multiresource objectives, tradeoffs among resource values are inevitable.

Water pollution and soil erosion can result when timber management and harvesting are conducted without adequate attention to proper safeguards. Increased levels of timber harvesting also could intensify conflicts with other land uses such as agriculture, recreation, wilderness, and wildlife.

The diversity of conditions on U.S. forests complicates the analysis of such effects beyond specific sites, but the capacity to trace and predict multiresource interactions at the State or regional level is improving as more information becomes available. Current efforts by the Forest Service and others to develop models of these interactions could improve understanding of resource tradeoffs involved in increasing timber production on both public and private lands.

Forest industry lands have high potential for increasing national timber supplies. The recent trend on industry lands has been away from "extensive" rudimentary forest practices and toward more intensive management, which probably will bring higher productivity in the future. Despite this trend, however, some industry forests are not managed intensively.

The forest industry is in a favorable position to increase yields on its lands for several reasons. First, industry lands on the average are naturally more productive than land in other ownerships, and tracts are large and tend to be located close to mills. Second, the large forest products firms, which own most of the industry land, ordinarily have access to capital for major management investments. Third, timber production is the primary ownership objective of these firms. Although the size of the industrial land base is no longer increasing at the rate it once did, intensive timber management could enlarge the forest industry's contribution to U.S. timber supplies significantly.

There is an opportunity for nonwood-based corporations to play a more important role in private forestland timber production. Several financial firms recently have offered investment opportunities in private nonindustrial forestland. The impact of such investments on forest management and ownership is still unknown, but significant capital may become available for intensive timber management if these investment programs continue to grow.

In addition, USDA landownership data suggests that nonwood-based corporations have major forestland holdings. These properties may enjoy some of the same advantages as forest industry lands in terms of their potential for increased production. More information about nonwood-based corporate holdings would be desirable to assess their possible contribution to U.S. wood supplies.

Private nonindustrial forest (PNIF) lands contribute nearly half of the industrial wood used in the United States, and their increased contribution can be expected as new local markets develop. Opportunities for more intensive timber management on PNIF lands exist but are complicated in some cases by ownership patterns and financial considerations.

The forest products industry obtains 47 percent of its roundwood from PNIF lands, which account for 58 percent of the U.S. commercial forestland base. In the South, about 60 percent of the region's wood comes from PNIF lands.

Net annual growth on PNIF lands has been increasing more rapidly than on other ownerships, and this growth rate could double PNIF output by 2030 if current trends continue. On the whole, therefore, PNIF lands can be expected to enlarge their contribution to domestic timber supplies without substantial increases in timber management activities. Far higher supply levels could be achieved through intensive management, but there are impediments to making such investments.

Lack of certainty about future markets, particularly in the North where hardwoods predominate, may discourage small landowners from investing in timber management activities that may not provide returns for decades. Also, many PNIF owners are unwilling to assume risks such as fire, weather damage, insects, disease or other catastrophes when safer, shorter term nontimber investments are available.

Changes in land use and ownership also may affect long-term management investments on PNIF lands. The total acreage of these lands is declining, especially in the South, due to competition from other uses, and further decline is expected in the future. Since PNIF lands change hands rapidly, only a small proportion is likely to be under single ownership for the length of time needed to grow a tree crop. Some PNIF lands are in parcels too small for economical management. Parcellation may be increasing in some locales, but regional and national data is fragmentary and inconclusive.

Nonfarmers have replaced farmers as the dominant owners of private nonindustrial forests. These new owners have less predictable ownership objectives, but in some cases they may have investment capital available for timber management.

Impediments to PNIF management may not be as great as many observers traditionally have believed. In general, higher timber output can be expected even if management levels remain the same. Still, some PNIF holdings offer appreciable opportunities for more intensive management. The cost effectiveness of limited public funds available for PNIF management incentives could be improved if directed towards those lands with the highest management potential. The forest products industry, through landowner assistance programs and long-term leasing agreements, may be even more important than government in putting management capital into PNIF lands.

While existing law provides some flexibility for temporary increases in timber harvest on Federal lands, statutory changes could be required if more acreage is to be allocated to timber production. Over the long run, however, more intensive timber management of lands already open to timber production could increase national wood supplies significantly. Harvest levels on national forests are set by a "nondeclining even flow" policy intended to ensure sustained yields in perpetuity, although temporary departures from this policy are legal under certain circumstances. For instance, a 1979 Presidential directive called for accelerated updating of land management plans for some national forests to increase the harvest of mature timber. Because of the simultaneous nontimber uses mandated by Federal law, however, major statutory changes could be required to open more Federal forestland to timber production than is currently allowed. Some Federal forestland, such as tracts being studied for possible wilderness designation, is in an indeterminate status regarding its potential availability for timber production. Nevertheless, more intensive management on lands now allocated to timber harvest could increase production, provided political and budgetary constraints are eased.

Characteristics and Productivity of U.S. Forests

The United States ranks third among the nations of the world in exploitable forest acreage and growing stock (table 22).* U.S. forests are highly productive, providing more industrial wood than any other country, including the Soviet Union, which has 3½ times more growing stock than the United States.

The suitability of U.S. forestland for timber is enhanced by favorable climatic conditions, especially in the Southern States, which result in greater annual growth and faster timber regeneration than in Canada or the U.S.S.R. Mature timber can be grown in 30 to 40 years in the South, for instance, while production of similar tree crops in parts of Canada or the U.S.S.R. may take two to three times longer.

There are well-developed transportation and manufacturing systems in the most heavily forested regions of the United States. In contrast, countries like Brazil and the U.S.S.R. would require significant investments in transportation before exploitation of remote interior forests even could begin. The majority of American processing facilities are located in the two most important timber areas—the Pacific Northwest and the South—which are accessible to the major markets of Japan and Western Europe. The United States also has a large number of different forest ecosystems that provide a wide variety of commercially important softwood and hardwood species (fig. 21).

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*No standardized international definitions are used by countries to identify exploitable forest areas. Some countries use more conservative criteria than others. Canada recently reduced its estimate of its exploitable forestland area significantly.

Table 22.—Countries With Largest Forested Areas

	Exploitable forest area (million ha)[a b]	Growing stock (million meters³ over bark)[c]			Industrial harvest (billion ft³) 1977
		Total	Coniferous	Broadleaved	
U.S.S.R.	389	74,710	62,000	12,710	10.0
Brazil	305	47,088	98	46,990	1.5
United States	195	20,132	12,906	7,226	11.5
Canada	191	19,645	15,571	4,074	5.1

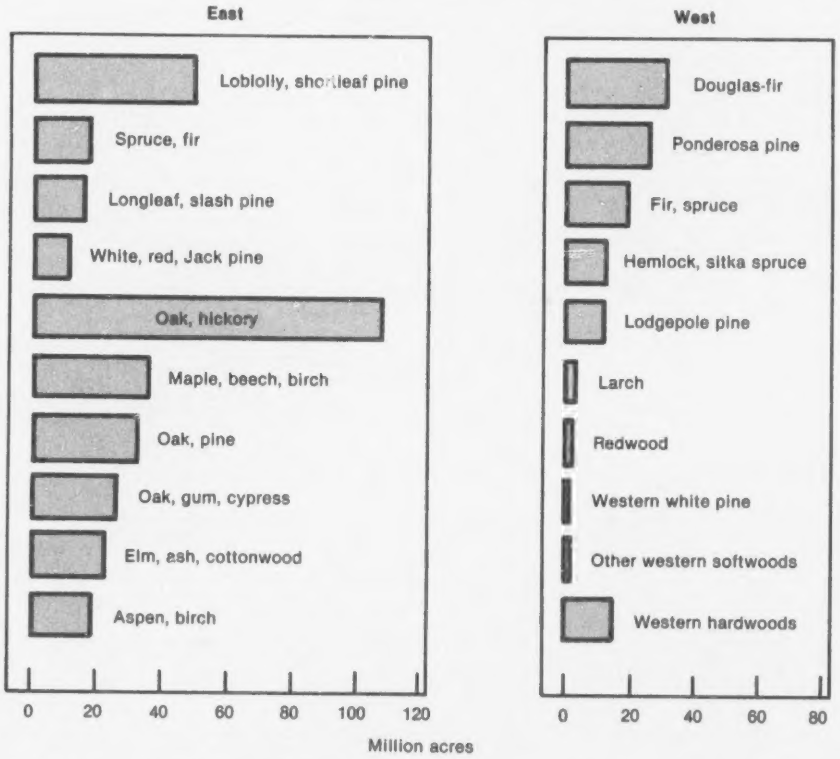
[a] Exploitable forest definitions differ by country. Some countries such as Canada have restrictive definitions that result in conservative estimates of exploitable forestland. Volume estimates for the U.S.S.R. include growing stock on some 110 million acres considered to be unproductive forestland.

[b] To convert hectares to acres, multiply by 2.471.

[c] To convert cubic meters to cubic feet, multiply by 35.31.

SOURCES: United Nations Food and Agricultural Organization, *Yearbook of Forest Products, 1979* (Rome, 1981); G. M. Bonner, *Canada's Forest Inventory 1981* (Environment Canada, 1982); United Nations Environment Program/Food and Agricultural Organization, *Los Recorsos Forestales de la American Tropical* (Rome, 1981); United Nations Economic Commission for Europe, *European Timber Trends and Prospects, 1950 to 2030* (Geneva, 1976); U.S. Department of Agriculture Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: 1982).

Figure 21.—Commercial Timberland Area by Type, 1977



SOURCE: U.S. Department of Agriculture, Forest Ser vice, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 122.

Reversing a historical trend toward apparent depletion, U.S. timber inventories have been increasing since at least 1952. Growth patterns are uneven, however, with irregular patterns in land clearing, tree planting, and harvesting causing waves or bulges in the distribution of tree sizes and species. Most increases in timber inventories have been in hardwood species, but most increases in timber demand in the past 20 years have been for softwoods. Although preferred species generally are in shorter supply than less valuable trees, and regional trends differ, higher levels of timber harvesting are biologically sustainable on U.S. forestlands.

Trees that are already growing will be the predominant source of industrial wood for the next 30 to 50 years. This is because of the long length of time required for tree crops to mature. However, if intensive timber management systems (applications of planned treatments to forestland aimed at increased production of industrial roundwood) are widely adopted, more timber could be available for harvest in the long term. In theory, "economic opportunities" for management intensification are promising. In particular, studies by the Forest Service and the Forest Industries Council have identified substantial opportunities for management investment in 25 States.[1] These investments would be expensive to make ($10 billion to $15 billion over 30 to 50 years, the course of a single rotation) but would boost growth tremendously.

Extent of Domestic Forests

Before the colonization of America, forests covered about half of the 2.3 billion acres that span the United States. Until 1800, removals of the original forest cover were relatively minor, but the westward expansion of the 19th century brought the clearing of nearly 300 million acres for farming, settlements, and other uses.[2] Timber generally was considered a nuisance and cleared land was often worth more than land supporting large timber stands. Regional cycles or waves in the amount of forest acreage have been significant; in some areas, in the past 200 years, forestlands more than once have been cut, used for agriculture, and again allowed to revert to woods.

The rate of decline of U.S. forestland leveled off around 1920, although slight declines continued through 1940. From 1940 to the early 1960's, acreage then increased slightly, because of farm abandonment and reversions of fields to forests in the Southeast, Northeast, and the upper Great Lakes States. During the late 1950's and early 1960's, the Federal soil bank program (now suspended) stimulated forestland expansion by encouraging farmers to plant trees on cropland. Since 1962, forestland area again has declined somewhat—chiefly because of expanded agricultural and developmental uses.

Today, only about one-third of the United States is forested (fig. 22), with the acreage divided about equally between the East and the West. This area—736 million acres in 1977—includes some land that is sparsely stocked with trees or otherwise unsuited for industrial timber production.

About two-thirds or 482 million acres of the total forestland area is classified by the Forest Service as "commercial." The commercial classification includes all forestland that is capable of growing 20 cubic feet (ft^3) of industrial wood per acre annually in natural stands and which has not been withdrawn from timber harvesting by statute or administrative action. Noncommercial forestland may produce fuelwood and some timber, but is generally not important for industrial forestry.

The commercial forest designation does not imply that all or even most of this land currently is used to supply timber markets. Only about 14 percent of the commercial base is owned by the forest products industry, the single group for which timber production is unequivocally the primary ownership objective (table 23). Twenty-eight percent is publicly owned and generally is managed for multiple uses including recreation, wildlife habitat enhance-

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[1] Forest Industries Council, *Forest Productivity Report* (Washington, D.C.: National Forest Products Association, 1980); and U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), pp. 246-255.

[2] Marion Clawson, "Forests in the Long Sweep of American History," *Science*, June 15, 1979, pp. 1168-1174.

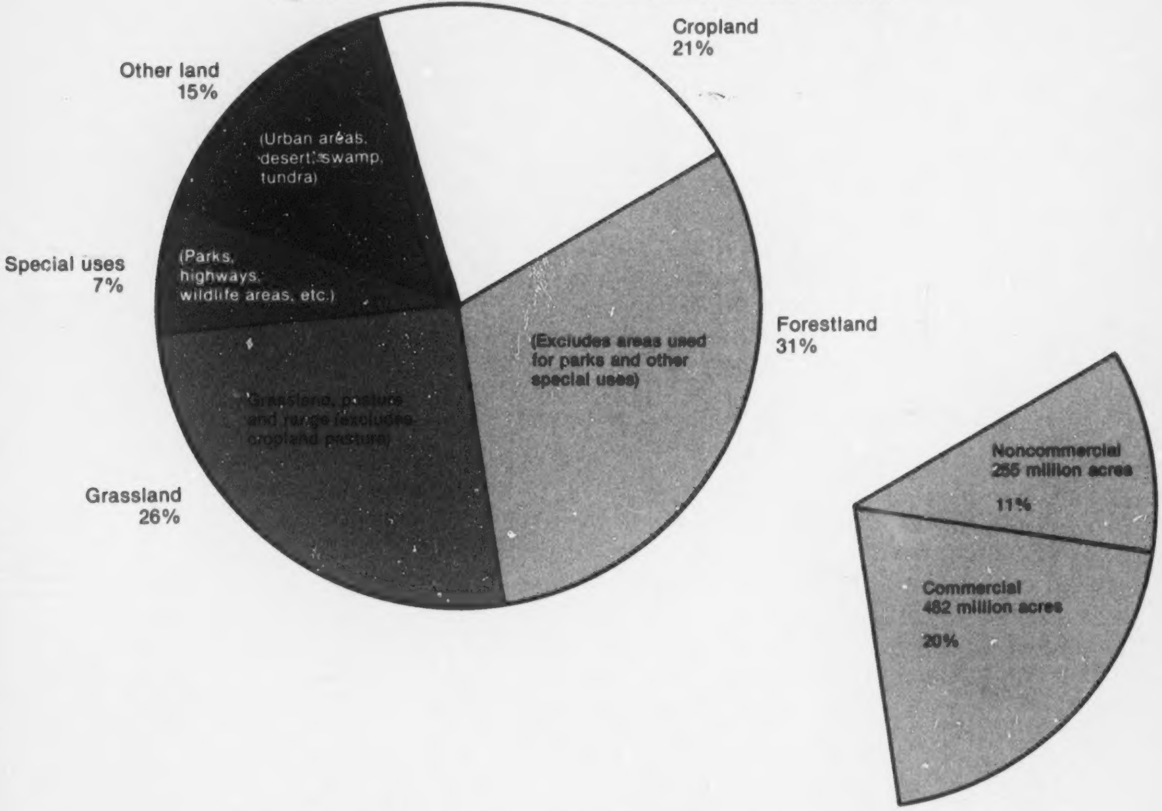


Figure 22.—Major Uses of Land in the United States, 1978[a]

[a] The estimates shown in this figure were derived by using several data sources, and may differ in some instances from other published data.

SOURCE: U.S. Department of Agriculture, *Major Uses of Land in the United States, 1978* (Washington, D.C.: U.S. Government Printing Office, 1982).

ment, and watershed protection in addition to timber production. Fifty-eight percent of the commercial base is PNIF held by over 7 million owners with diverse objectives and management capabilities. Although most PNIF land is not owned primarily for timber production, nearly half of the industry's wood supplies come from this acreage.

Regionally, the South has the most commercial forestland and makes the greatest contribution to nationwide timber supplies (table 23). The Pacific coast supplies the most softwood. Although the North has about one-third of the commercial acreage, the forest products industry is less developed there than in the South or on the Pacific coast.

Table 23.—Area of Commercial Timberland in the United States, by Owner Class and Region, 1977

Owner class and region	Million acres[a]	Percent of total
National Forest	88.7	18.4
Other public	47.0	9.7
Forest industry	68.7	14.3
Farm and miscellaneous private	278.0	57.6
Total	482.4	100
North	166.1	34.4
South	183.0	39.0
Rocky Mountains	57.8	12.0
Pacific coast[b]	70.5	14.6
Total	482.4	100

[a] To convert acres to hectares, multiply by 0.4047.
[b] Includes Alaska.

SOURCE: Adapted from Brian R. Wall, *Trends in Commerical Timberland Area in the United States by State and Ownership, 1952-1977, With Projections to 2030* (Washington, D.C.: U.S. Government Printing Office, 1981), p. 10.

Variation in Productivity of Forestland

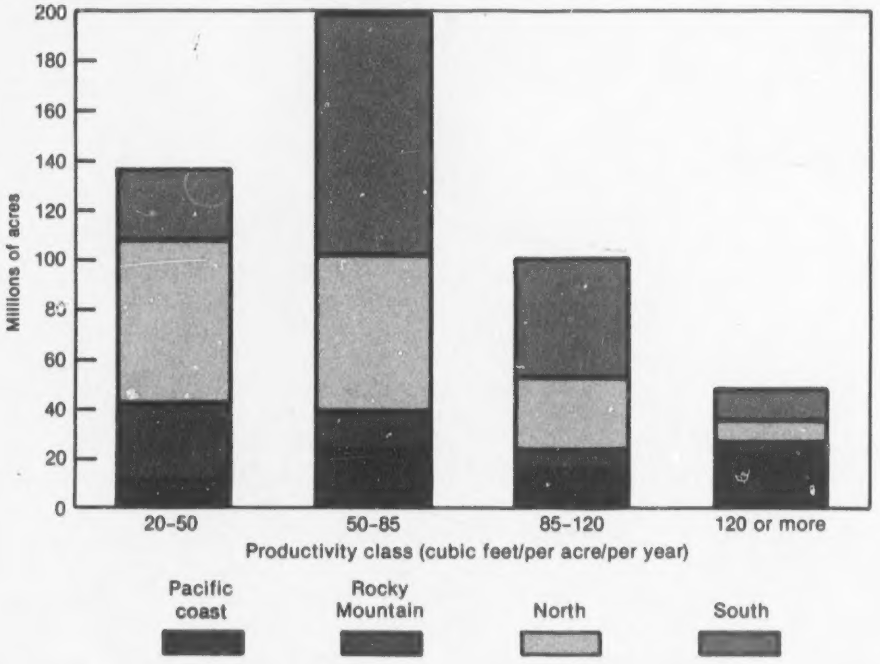
Nearly all forestland in the Eastern United States (93 percent) meets the commercial standard for productivity. In other words, it is capable of producing the Forest Service's designated minimum of 20 ft³/acre/year in natural stands. In the Rocky Mountain and Pacific coast regions respectively, only 42 and 33 percent of the forestland area is considered commercial. The lower proportion of Western commercial acreage arises mostly from the pervasiveness of low productivity forests, such as pinyon-juniper in the Southwest and mixed conifers in interior Alaska. Administrative restrictions on timber management on Federal land also play a role.

Natural productivity also varies greatly within the commercial timberland classification (fig. 23). About 28 percent of the commercial forestland is capable of growing 20 to 50 ft³/acre annually. This low-quality acreage may provide timber and fuelwood, but ordinarily it is not well suited for intensive timber production. Another 40 percent is in an intermediate range of productivity at 50 to 85 ft³/acre/year.

The remaining 30 percent of commercial forest is "prime timberland" capable of producing 85 ft³ or more of industrial wood per acre per year in natural stands. All else being equal, management investments on such lands will be more cost effective than investments on less productive lands. In 1970, nearly 48 percent of the productive capacity of all commercial forests was on the 34 percent of the commercial forest base that was considered prime timberland.[3]

Even within the prime category, there is a wide range in productivity. Some forestland in

Figure 23.—Commercial Timberland Area by Productivity Class and Region, 1977



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), pp. 350, 355.

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[3] U.S. Department of Agriculture, Forest Service, *USDA Prime Forestlands Program,* Mimeograph, May 23, 1977, p. 3.

the Pacific Northwest is naturally capable of producing 225 ft^3 of wood per acre per year. Thus, the productive capacity of such lands without intensive management is 10 times greater than the productivity of marginal commercial forestland, and nearly three times greater than land on the threshold of qualification as "prime timberland."

The distribution of prime forestland also varies among ownership classes (table 24). As a general rule, forest industry lands include proportionately more land in the better site classes than public or private nonindustrial forestland. This is especially true in the West, where two-thirds of the forest industry's holdings are prime lands and nearly half of them are capable of producing over 120 ft^3/acre/year.

Table 24.—Area of Commercial Forestland in Site Classes Capable of Producing 85 Cubic Feet of Wood per Acre or More, by Ownership, in 1977

	Million acres[a]	As a proportion of acres in ownership category (percent
National Forests	27.0	30.4
Other public	11.5	24.5
Forest industry	30.3	44.0
Farm, miscellaneous	77.4	27.8
All ownerships	146.2	30.3

[a]To convert acres to hectares, multiply by 0.4047.

SOURCE: Adapted from U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C.: 1982), pp. 350-359.

Decline in Commercial Acreage

The Forest Service estimates that commercial forestland declined by about 5 percent between 1962 and 1977—from 509 million acres to 482 million acres. Most of this decline resulted from diversion to other uses, such as agriculture, urbanization, and wilderness; some is attributed to reclassification of land. The decline in acreage represents a reversal of an earlier trend toward a slight increase in forestland that occurred between 1920 and 1952. Although pressures on forests are expected to continue, less rapid declines in forest acreage for the coming decades are projected by the Forest Service and other resource analysts (table 25).[4]

Most of the 1962-77 nationwide decline was in private forests owned by farmers or other nonindustrial parties. Some of this private land was purchased by the forest products industry, whose holdings increased by about 7 million acres during the period, making the net decline in private holdings about 19 million acres. Na-

Table 25.—Area of Commercial Timberland in the United States, by Owner Class and Section, 1952, 1962, 1970, 1977, and Projections to 2030[a] (million acres)

					Projections				
Owner class and section of United States	1952	1962	1970	1977	1990	2000	2010	2020	2030
National Forest	94.7	96.9	94.7	88.7	81.3	80.4	79.8	79.2	78.8
Other public	49.0	46.8	46.9	47.0	46.6	46.5	46.4	46.4	46.4
Forest industry	59.5	61.6	67.0	68.7	70.9	72.2	72.7	73.0	73.1
Farm and miscellaneous private	296.1	304.1	287.8	278.0	268.8	261.8	256.1	251.5	247.9
Total	499.3	509.4	496.4	482.4	467.6	460.9	455.0	450.1	446.2
North	168.8	170.9	168.6	166.1	164.2	162.5	160.9	159.1	158.5
South	192.1	199.9	192.5	188.0	182.5	179.7	177.2	175.2	172.9
Rocky Mountains	63.9	64.4	62.1	57.8	56.2	55.2	54.1	53.6	53.0
Pacific coast[b]	74.5	74.2	73.2	70.5	64.7	63.5	62.8	62.2	61.8
Total	499.3	509.4	496.4	482.4	467.6	460.9	455.0	450.1	446.2

[a]Data for 1952 and 1962 as of Dec. 31; other years as of Jan. 1.
[b]Includes Alaska.

SOURCE: U.S. Department of Agriculture, Forest Service, *Trends in Commercial Timberland Area in the United States 1952-77, With Projections to 2030* (Washington, D.C.: 1981), p. 10.

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[4] Brian R. Wall, *Trends in Commercial Timberland Areas in the United States by State and Ownership, 1952-1977, With Projections to 2030*, General Technical Report WO-31 (Washington, D.C.: U.S. Government Printing Office, April 1981), p. 7. For discussion of agricultural competition for forestland, see Thomas N. Schenartz, "Dynamics of Agricultural Land Use Change," *Agricultural Land Availability: Papers on the Supply and Demand for Agricultural Land in the United States* (Washington, D.C.: U.S. Government Printing Office, July 1981), pp. 187-216.

tional forest acreage also declined by 8.2 million acres as a consequence of wilderness designations and other administrative actions that preclude timber harvesting. Most of the Forest Service land that shifted to noncommercial purposes was in the low productivity range (between 20 and 50 ft^3/acre) and was thus of marginal value for timber production.

The greatest regional decline in commercial forestland was in the South, the Nation's fastest growing region between 1970 and 1980.[5] Here, about 12 million acres were diverted to other uses between 1962 and 1977 according to the Forest Service. In particular, the South's "prime timberland" declined **very** rapidly—a matter of special concern because of the region's importance to national timber supplies. Between 1970 and 1977, the decline was about 6 million acres—a 10-percent reduction in the region's prime acreage in 7 years. Loss of prime timberland apparently exceeded the region's total timberland loss for the period, which was 4.7 million acres, because some poorer quality land reverted to forest during the same timeframe.

Shifts between agriculture and forestry probably will continue to be the major factor influencing forestland acreage, although the extent is unclear. Rapid changes in agricultural land requirements have made it extraordinarily difficult to project long-term interactions between forestland and cropland. Projections made in the 1960's and early 1970's, when grain surpluses were common, assumed that cropland needs would decline due to improved yields per acre. During the 1970's, however, expanded world demand for U.S. food, together with the lifting of farmland set-aside programs by the Federal Government, led to a very rapid expansion of cropland. Projections by the U.S. National Agricultural Land Study (NALS) made in 1979-80 assumed that cropland requirements would expand rapidly and would accelerate conversion of forestland to agricultural use. Specifically, NALS concluded that most of the 31 million acres of forestland that have a high or medium potential for crop production could be cleared and converted to crop use by 2000.[6] Most of this converted land presumably would be commercial forestland, and two-thirds of it would be located in the South. Some agricultural land reverts to forest each year, but generally is not stocked with commercially important species.

Since the NALS study was published in early 1981, the agricultural situation has again changed dramatically. In the 1980-82 period, enormous grain supplies similar to those of the 1960's developed once more, and the Reagan administration instituted a payment-in-kind (PIK) cropland set-aside program for eligible farmers. In 1983, under the PIK program, agriculture activities on 82 million acres of cropland will be restricted to eligible conservation uses during the growing season.

Urban and other developmental uses such as water reservoirs also will affect the forestland base. For the first time in memory, populations in rural areas grew at a faster rate than in metropolitan areas between 1970 and 1980, chiefly as a result of in-migration of people to nonmetropolitan counties. This shift occurred in all regions of the country, including high wood production areas.

Out-of-Date Forest Surveys

Forest Service acreage estimates are based on periodic State forest surveys, which, at the time they are taken, are the most reliable and consistent sources of information available. However, because they are conducted in individual States only on an average of every 12 years, many surveys are out-of-date by the time they are used to assess nationwide trends; this was the case in 1952, 1962, 1970, and 1977.

The 1977 national estimate of commercial forestland, used for the 1980 assessment required under RPA and for subsequent analyses of timber supply and demand trends, exemplified this timing problem. In 1977, the most recent forest survey had been conducted prior to 1970 in 22 States. The Forest Service reported some of these estimates without change in compiling its 1977 data; in other instances, revisions were made, but these were not based on field data and consequently carry a higher likelihood of error. Forest surveys completed after 1977 show important differences with the acreage figures issued in 1977.

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[5] For discussion of southern land use conflicts and their relationship to the forest products industry, see Robert G. Healy, "Land in the South: Is There Enough to Satisfy Demands," *Conservation Foundation Letter*, September 1982; and Schenartz, "Dynamics of Land Use Change," op. cit.

[6] U.S. National Agricultural Lands Study, *Final Report* (Washington, D.C.: U.S. Government Printing Office, 1981), pp. 8-10, p. 13.

Budgetary and political constraints underlie the Forest Service's difficulty in increasing the frequency of forest surveys. Congress, through the Forest and Rangeland Renewable Resources Research Act of 1978 (Public Law 95-307), recognized that adequate information was a key component of RPA planning. While Congress initially provided expanded funding for surveys, current budget cuts may slow the survey schedule again. To overcome some of the scheduling problems, in some States, the Forest Service and State agencies have cooperated in producing "midcycle updates." Another option would be to give greater survey priority to the most important timber producing States and to those where rapid changes in inventories and acreage are expected.

Soil Conservation Service Estimates of Non-Federal Forestland

In addition to the Forest Service, SCS also compiles data on non-Federal forest area. SCS does not distinguish between commercial and noncommercial forestland, in contrast to the Forest Service. SCS's estimate of non-Federal forest area in 1977 was 74 million acres less than the Forest Service's estimate for the same year. Both figures were reported to Congress by USDA in 1980. The higher Forest Service estimate was part of the 1980 assessment required by RPA, while the lower SCS figure was reported in the 1980 assessment for the parallel Soil and Water Conservation Act.

The two USDA agencies are working to resolve this discrepancy and have agreed to use common forestland acreage figures in future assessments. Nevertheless, the situation demonstrates some of the difficulties in providing decisionmakers with accurate national level data on natural resources.

According to the Forest Service, non-Federal forestland amounted to 451 million acres, including noncommercial forestland, in 1977. According to SCS, which does not distinguish between commercial and noncommercial forestland, only 377 million acres were non-Federal forestland in 1977.[7]

Nearly half the difference is attributable to the fact that SCS classifies some transitional forest-range ecosystems as rangeland, while the same land is called forest by the Forest Service. As much as 35 million acres of transitional land may be involved, according to a report prepared for the U.S. National Agricultural Lands Study in 1980.[8] Most of this land would not be considered commercial forestland by the Forest Service's definition.

Additional differences are attributable to the fact that SCS includes more forestland in its "urban or built up" classification than does the Forest Service, and some land may be classified as native pasture by SCS but forestland by the Forest Service. The timing problems associated with uniform reporting of Forest Service data at a given date may partially explain some of the difference. The 1967-77 period witnessed major land use changes in agriculture and development that could be expected to affect forestland, and Forest Service estimates may not fully reflect these. The 1977 SCS inventory data, on the other hand, was compiled in a 2-year period and estimates were based solely on field data. Several technical difficulties have been identified with the SCS field data, however, which may have resulted in overstatement of the magnitude of shifts in land use during the 1970's.

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[7] U.S. Department of Agriculture, Forest Service, *An Assessment of the Forest and Range Land Situation in the United States* (Washington, D.C.: U.S. Government Printing Office, January 1980), table 2.3, p. 35; U.S. Department of Agriculture, *Soil and Water Resources Conservation Act of 1980 Appraisal Part I* (Washington, D.C.: U.S. Government Printing Office, 1981), p. 49.

[8] Ernest McGill, Allen Hidlebaugh, and Joseph Yovino, "Federal Data on Agricultural Land Use," *Agricultural Land Availability: Papers in the Supply and Demand for Agricultural Lands in the United States*, prepared for the U.S. National Agricultural Lands Study and printed for use of U.S. Senate Committee on Agriculture, Nutrition, and Forestry. (Washington, D.C.: U.S. Government Printing Office, July 1981), table 1, p. 246.

As this report was going to press, the two agencies appeared close to reconciling key differences associated with their 1977 estimates.*

Anticipated Further Declines in Forest Acreage

To estimate long-term timber supplies, assumptions must be made about the amount of forestland that will be available in the future. Predicting future land use trends is still little more than guesswork. The magnitude of recent trends affecting forestland, such as increased diversion of forestland to agriculture and developmental uses, was not anticipated by analysts in the 1960's. Current analysis is equally subject to uncertainty.

There is little surety that the dramatic land use changes that occurred in the 1970's will be repeated. The 1981-82 recession, which brought slumps in housing demand and slackened growth in world markets for U.S. food, presumably has reduced conversion pressures on forestland. If agricultural surpluses keep mounting, forestland acreage could begin to increase as agricultural land is retired from production. Such land, if allowed to naturally revert to forest, probably would be poorly stocked with commercial tree species. However, if government programs such as the soil bank of the late 1950's and early 1960's were reinstituted, planting of commercial species on land that is now cropped could result.

Based on trends through 1977, it is reasonable to assume that forestland will continue to be diverted to other uses. The Forest Service projections used in modeling long-term timber supplies show commercial forestland declining at a net average rate of about 700,000 acres annually over the next 50 years. This projected 36 million acre net decline would reduce the commercial forestland base by about 7.5 percent from what it was estimated to be in 1977.[9]

The Forest Service anticipates that most of the decline would result from conversion of private nonindustrial lands to other uses. Commercial land on national forests would decline slightly due to wilderness designations, while commercial industry lands would increase somewhat. All regions of the country would experience a decline in commercial forest, but the most significant decline would be in the South (table 25).

The projected decline is less than half the rate of decline measured by the Forest Service in the 1962-77 period, but it is consistent with the longer term trend seen in Forest Service statistics between 1952 and 1977. There are some technical difficulties with this projection due to the out-of-date information used in the 1977 baseline data. Recently completed State surveys in Arkansas and Michigan, for example, show that 1977 RPA forestland acreage projections in those States were overstated. The 1978 survey in Arkansas showed that commercial forest acreage in the State had already declined to the level that had been projected for 2010.[10] Arkansas' 1977 projection was based on the State's 1969 survey, but Arkansas forestland was greatly affected by expanded soybean production in the mid-1970's, a change apparently not incorporated into 1977 projections. The preliminary 1980 Michigan forest survey data shows present commercial acreage to be about what was projected for the period from 2010 to 2020.[11]

Close monitoring of forestland acreage is needed in the coming years. A revived economy coupled with potential renewed growth in agricultural exports could produce a more rapid decline in commercial forest acreage than has been projected. If the 1962-77 trend extended through the year 2000, commercial acreage would decline by 41.4 million acres rather than by the projected 21.5 million acres.

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*Shortly after OTA released a review draft of this assessment, the Forest Service and the Soil Conservation Service moved rapidly to resolve their differences. Agreed upon statistics for State by State and national non-Federal forestland acreage were expected to be released shortly as the report went to press.

[9] Wall, *Trends in Commercial Timberland Areas in the United States*, op. cit., p. 9.

[10] The projected level of decline, based on 1969 data, is in Ibid, p. 17. The new survey is in William W. S. Van Hees, *Arkansas Forests: Trends and Prospects*, Forest Service Resource Bulletin SO-77 (Washington, D.C.: Government Printing Office, 1980). Arkansas forests declined 9 percent between 1969 and 1978.

[11] Cited in W. Brad Smith, "Michigan Forest Inventory Fieldwork Completed," *Northern Logger and Timber Processor*, April 1982, pp. 20-22.

Availability of Commercial Forestland for Intensive Management

Merchantable trees eventually may be harvested from most commercial forestland. As a practical matter, however, only part of the forestland base is worth special management treatment. Since some lands are better suited for such investment than others, the issue has arisen on how to direct limited public incentives and private investment capital to acreage offering the most cost-effective intensive management opportunities.

Factors affecting a tract's suitability for intensive management include:

- management profitability;
- parcel or stand size;
- market proximity;
- landownership objectives;
- accessibility; and
- site specific variables such as natural productivity and slope.

To demonstrate the information systems needed to portray the interaction among these factors, OTA asked the Forest Service's Southeast Forest and Range Experiment Station to screen its data on private nonindustrial commercial forestland. The Southeastern Station operates the Forest Information Retrieval System (FIR)—a sophisticated system that is able to cross-reference inventory data for the five Southeastern States on local, county, State, and regional levels without double-counting acreage. Low productivity, lack of accessibility, and other factors were assumed to limit the feasibility of tree planting and silvicultural activities. Although these factors are likely to impede intensive management activities, the specific criteria chosen (such as exclusion of tracts of 10 acres or less) are somewhat arbitrary and may not necessarily preclude economical management in all circumstances.

Of the 64 million acres of private nonindustrial lands in the region, only 34 million acres were not affected by the selected management-constraining factors. The 30 million acres of affected lands currently contain 40 percent of the region's PNIF softwood growing stock and 50 percent of the hardwood growing stock. This land can be expected to provide timber, but silvicultural activities on the affected lands would presumably be less cost effective than investments on nonaffected lands (table 26). The FIR analysis does not include ownership objectives or financial limitations on management and therefore is not a complete picture

Table 26.—Screening of Land-Related Management Constraints on Private Nonindustrial Forestland in the Southeast

Step	Description	Maximum PNIF discount			Residual		
		Commercial forest (acres)	Growing-stock volume (thousand cubic feet)		Commercial forest (acres)	Growing-stock volume (thousand cubic feet)	
			Softwood	Hardwood		Softwood	Hardwood
1	Total area and volume	—	—	—	87,999,537	49,040,888	53,279,042
2	Minus public and forest industry holdings	—	—	—	64,089,209	34,670,624	40,649,933
3	Minus remaining stands on poor sites (site 5)	10,523,496	3,289,981	3,666,237	53,565,713	31,380,643	36,983,696
4	Minus remaining stands 10 acres or less	14,673,950	8,557,411	7,429,750	40,936,396	23,516,864	30,072,922
5	Minus remaining stands that are inaccessible	668,975	298,788	804,547	40,512,090	23,330,665	29,384,892
6	Minus remaining stands with difficult operability	6,857,375	2,383,606	7,663,517	36,434,599	22,036,160	23,959,028
7	Minus remaining stands in strips, stringers, and strands	4,017,883	1,582,757	5,259,451	33,787,967	21,099,625	20,184,492
8	Minus remaining stands that are poorly stocked	12,696,671	1,998,743	3,142.848	28,890,905	20,188,588	18,826,225

SOURCE: Data and table provided by the U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.

of the factors needed for a comprehensive assessment.

The screening described illustrates the capabilities of advanced information systems to provide refined data about forestland management opportunities. Broader application of such systems could provide decisionmakers with a more realistic picture of feasible goals both regionally and nationally.

A better national assessment of the management potential of U.S. forestland ultimately may require a modified conceptual framework as well as additional data. One possibility, proposed by resource economist Marion Clawson, would be to incorporate economic and environmental considerations into site class designations.[12] Three classes of commercial forestland could be established:

1. **Class A**—lands capable of producing at least 85 ft³/acre per year in natural stands, able to yield a 10-percent return on management investments in real terms, and posing no serious environmental problems;
2. **Class B**—50 to 85 ft³/acre/year, less than 10-percent return on investment, and no serious environmental problems; and
3. **Class C**—less than 50 ft³/acre/year, and/or serious environmental or other constraints that would preclude commercial operations. Other analysts have proposed similar classification systems, although the specifics differ.

The growing importance of fuelwood also points to a need to redefine commercial forestland. In some areas, rising fuelwood use has increased demand for wood growing on lands that are marginal for producing industrial roundwood. In the Southwest, for example, large areas of pinyon-juniper classified as noncommercial are being utilized for energy production.[13] Hence, it may be necessary in the future to take into account both industrial and nonindustrial commercial uses for wood when assessing commercial forestland.

Growing Stock Volumes

The Forest Service estimated that commercial growing stock* in 1976 amounted to over 710 billion ft³.[14] Softwood species, currently preferred for most high-volume wood uses, comprise about two-thirds of the stock; hardwoods comprise one-third.

About half the softwood volume is in the Pacific coast region; the South and the Rocky Mountain areas each have about one-fifth of the softwood growing stock, while the North has about 10 percent (fig. 24). Over 90 percent of the hardwood stock is in the Eastern United States—half in the North, 40 percent in the South. The South, therefore, has a high proportion of both hardwood and softwood volumes. Even though only one-fifth of the Nation's standing softwood volume is in the South, the region accounts for more than half the annual growth of softwoods.

Ownership of inventories varies significantly by region. About 56 percent of the softwood inventory is in public ownership, primarily in the old-growth stands of the western national forests. The forest products industry currently owns relatively small volumes of sawtimber in the Pacific Northwest, because most old-growth has been cut; many of these harvested areas now support rapidly growing second-growth stands. Most growing stock in the South is located on private nonindustrial lands and a lesser amount on forest industry lands.

Current efforts to manage forestland are aimed primarily at increasing the area in softwood species or in reducing the hardwoods among existing softwood stands. Emphasis on softwood management is largely a function of the higher demand for softwood timber, the resulting higher value of such wood and projections of its increasing economic scarcity.

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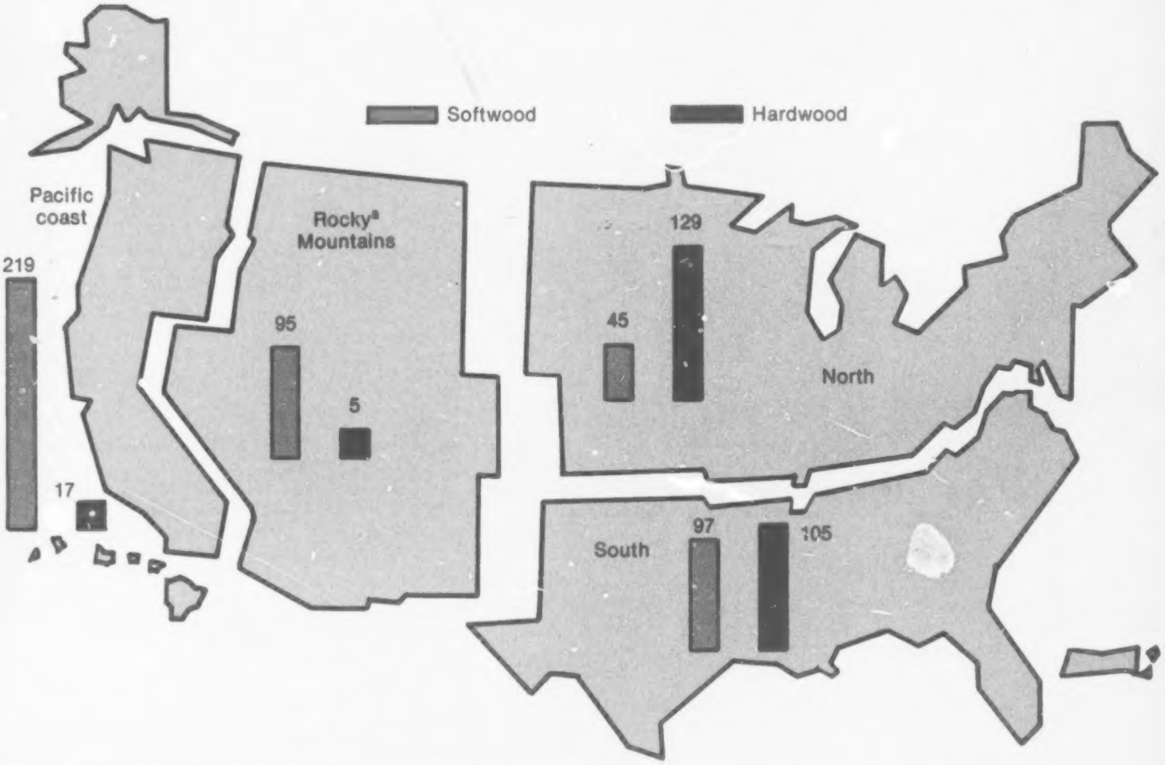
[12] Marion Clawson, "An Economic Classification of U.S. 'Commercial' Forests" *Journal of Forestry*, November 1981, pp. 727-730.

[13] See Michael L. Samuels and Julio L. Betancourt, "Modeling Long-Term Effects of Fuelwood Harvests in Pinyon-Juniper Woodlands," *Environmental Management*, vol. 6, pp. 505-575, for discussion.

*Net volume of live sawtimber and poletimber trees from the stump to a minimum 4 inch top of the central stem or to the first limbs.

[14] *Analysis of the Timber Situation*, op. cit., p. 182.

Figure 24.—Timber Inventories by Region, 1976 (billion cubic feet)



[a]Data for Kansas, Nebraska, North Dakota, and eastern South Dakota included in the North.

SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 158.

Much less attention has been given to hardwood management because hardwood growth in general greatly exceeds removals. Desirable and undesirable hardwood species may be intermixed in a stand, thus complicating harvesting and processing. In many hardwood forests, "high grading"—removal of high-value trees—has left mature stands of hardwood species that are currently undesirable from an industrial perspective.

Growing stock volumes comprise only part of the potentially usable woody biomass in forests. Nongrowing stock sources—limbs, tops, and rotten and small trees—currently account for 7 percent of softwood and 14 percent of hardwood industrial wood supplies and also are important for fuelwood. Technological advances in harvesting such as whole tree chippers that convert the entire above-ground portion of trees into chips, may expand the importance of nongrowing stock sources of wood, as may fuelwood demands and manufacturing processes able to use wood chips.

In 1980, the Forest Service established a National Tree Biomass Compilation Committee to gather more precise information about potentially usable above-ground woody biomass (growing stock plus nongrowing stock wood). Preliminary national estimates of tree biomass were issued in late 1981[15] (fig. 25).

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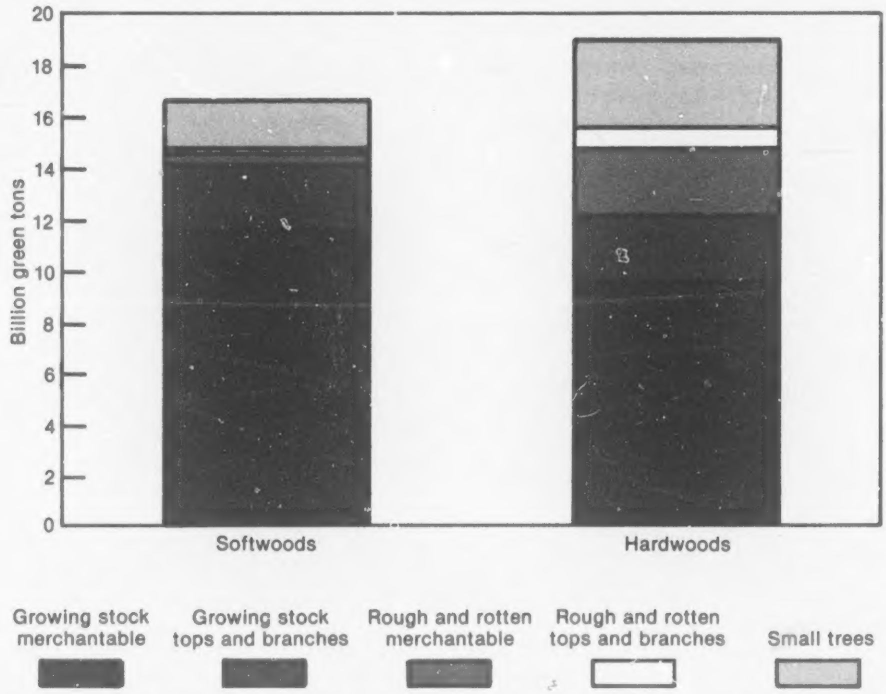
[15] U.S. Department of Agriculture, Forest Service, *Tree Biomass–A State of the Art Compilation,* General Technical Report WO-33 (Washington, D.C.: U.S. Government Printing Office, November 1981).

Figure 25.—Biomass on Commercial Forestland



SOURCE: Derived from U.S. Department of Agriculture, Forest Service, *Tree Biomass—A State of the Art Compilation* (Washington, D.C.: U.S. Government Printing Office, 1981), p. 5.

Because of economic constraints, as well as possible harm to soil, wildlife, and future tree growth, however, only a portion of the nongrowing stock biomass actually could be utilized.

Resource Implications of Increased Wood Fuel Demand

The effects of the recent growth in demand for wood fuel (discussed in detail in ch. IV) on the Nation's forest resources are difficult to predict. Continued growth in wood fuel consumption presents both opportunities and problems for timber management.

It is clear that supplies of woody biomass in domestic forests could sustain higher levels of fuelwood use than at present without affecting industrial wood supplies. The Office of Technology Assessment's 1980 report, *Energy From Biological Processes,* concludes that the biological capacity exists to produce between 4 and 10 quadrillion Btu (Quads) of energy per year—two to four times current levels—mostly through utilization of wood wastes, logging residues, dead wood, management thinning, etc.[16] The Forest Service's 1981 biomass inventory also showed large quantities of potentially available biomass that could be utilized without affecting merchantable portions of trees.

Fuelwood for residential use already has reemerged as an important timber crop in some areas. A sustained market for residential fuelwood could have positive effects on industrial wood supplies if properly managed. It could stimulate timber stand improvement activities on private nonindustrial forests, for example, because trees of little current commercial value are often suited for fuelwood. This could enhance growth of the remaining trees by reducing crowding, an important problem on some forestland. Harvesting residues, which are normally left behind in the forest where they can increase the cost of regeneration as well as create fire hazards, are now sometimes removed for fuel.

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[16] *Energy From Biological Processes* (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-E-124, 1979), p. 24.

However, there are no guarantees that fuelwood harvesters will confine their removals to trees that are of little value to the forest products industry. In some areas, markets for fuelwood already are stronger than for industrial roundwood. Many fuelwood harvesters may be unconcerned about restricting removals to nonindustrial timber and may harvest trees that are more valuable as nonfuelwood. This is less likely to be a problem with high-value mature trees than for young trees that could provide high-value forest products if left to mature.

In addition, a large number of inexperienced fuelwood harvesters could exacerbate environmental damage to forestlands. Improper harvesting can result in increased water pollution, soil erosion, and damage to fish and wildlife habitat. Only about 12 percent of homeowners who cut fuelwood from their own land in 1981 consulted a professional forester, according to the Forest Service.[17]

Clearly there is a need for more information about fuelwood use and its ramifications for forest management. Current levels of residential fuelwood use (40 million to 43 million cords annually) are several times higher than estimated by the Forest Service for 1976 (6 million cords per year) and greatly surpass levels initially projected for 2030 (26 million cords). Although a Forest Service Forest Products Laboratory study, to be published soon, has improved the understanding of key aspects of residential fuelwood harvesting (see box F), it is not yet clear what proportion of residential fuelwood is coming from commercially important forestland or what kinds of trees (industrial quality, nongrowing stock, or rough and rotten trees) predominate in fuelwood harvests.

Nontimber Values of Forestland

Domestic forestland serves a wide variety of uses in addition to timber production (table 27). These uses include watershed and soil protection, fish and wildlife habitat, grazing, landscape esthetics, and recreation. Also, significant energy and mineral resources are found on domestic forestland, both public and private.

Conflicts between timber production and other land uses, such as wilderness preservation, are unavoidable to some extent. Commercial timber management and harvest necessarily disturb natural forest ecosystems, although the degree of disturbance varies greatly depending on the practice used, site conditions, and the care that is taken to minimize harm. For example, silvicultural application of herbicides, pesticides, and fertilizers, if not properly done, can adversely affect water quality, fish, and wildlife. Timber harvest and associated logging roads and skidding activities disturb the soil and often lead to increased soil loss and sedimentation of streams, at least temporarily. Erosion problems may continue if stand regeneration is not accomplished promptly. Stand conversion to different species also radically alters the previous natural ecosystem.

Interactions among the various objectives of forest management are often complex. Some land uses such as grazing can interfere with timber growth if improperly handled, but are compatible with timber production if precautions are taken. Timber production can improve some kinds of wildlife habitat by producing increased forage after harvest, but other kinds of wildlife, such as those that are dependent on mature forests for habitat, may be adversely affected. In general, however, forestlands can be managed to produce a mixture of economic and noneconomic values important to society, even though some tradeoffs cannot be avoided.

Multiple use management has long been a key tenet of national forest policy and also is

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[17] U.S. Department of Agriculture, Forest Service, "Residential Fuelwood Use in the United States: 1980-81," draft research paper, Forest Products Laboratory, March 1983.

Box F.—Wood Fiber for Fuel

Fuelwood (or firewood), once the primary source of heat for American homes and businesses, was relegated to footnote status in most government energy reports prior to the 1973 oil embargo. The post-embargo rise in fuelwood use was so rapid that adequate estimates of residential fuelwood consumption were not available until surveys were conducted in 1980-81 by the Forest Service and the Department of Energy. The unexpectedly high levels of fuelwood use in the last few years raise significant forest management issues and are intensifying competition between homeowners and the forest products industry in some areas.

The following are among recent findings related to wood fuel:

- According to preliminary statistics prepared by the Forest Service Forest Products Laboratory, residential fuelwood usage during the 1980-81 heating season amounted to 42.1 million cords. By contrast, the total forest products industry harvest of pulpwood in 1979 amounted to 86 million cords.
- Thirty million cords of the residential fuelwood was self-cut by the user; the rest was obtained from mill residues or purchased. About 27 percent of the self-cut wood came from industrially merchantable trees. It is not known what proportion of the mill residues or purchased cordwood came from industrially merchantable trees.
- Millions of Americans are now harvesting wood for residential fuel. Some 3.9 million households cut fuelwood from their own land. In addition, 3.4 million other households cut fuelwood from private land they do not own.
- An estimated 12 percent of those who cut from their own land stated that they cut their wood based on the advice of a professional forester.
- About 11 million cords of residential fuelwood were acquired, averaging 1.5 cords per purchase, at $85 per cord. Variations in both volume and price paid were great, with those buying larger quantities paying less per cord, and those buying smaller quantities (less than a third of a cord), reportedly paying typically more than twice the average—$193 per cord.
- Fuelwood permits for national forests have increased tenfold in the last 10 years, and legal removals have increased from 400,000 to 4 million cords. National forest administrators are trying to manage fuelwood harvests, but there are severe problems with fuelwood thefts. The number of reported thefts increased over sixfold between 1971 and 1980, and these thefts are considered one of the top three law enforcement problems in the National Forest System.
- Wood fuels are beginning to be utilized by commercial and industrial establishments that are not part of the forest products industry. A recent nationwide study which compared wood-fired systems to energy production based on other fuels has found that wood energy systems are in many cases economically attractive. Wood fuels are particularly competitive in the South, the Northeast, and the North Central region, especially for residential and small industrial applications.
- A recently released American Paper Institute study concluded that the burning of waste paper in municipal powerplants will present major competition for recyclable fiber (now accounting for 25 percent of the fiber requirements of the paper industry) in coming decades. Waste paper exports, which constitute a major share of U.S. wood fiber exports, also may be affected if municipal burning accelerates.
- International trade in wood fuels, long thought impractical, is now being contemplated seriously in some areas. Shell International reportedly expects trade in densified wood fuels to develop in the Far East. And Minnesota and the Seaway Port Authority of Duluth are examining the prospects for exporting wood fuels from that State.

Table 27.—Classification of Renewable and Nonrenewable Resources

Resource	Kind of management required	Time required to replenish consumptive use
Herbage (livestock)	Intensity of grazing must be balanced with annual growth	One year
Fish and wildlife	Varies with species that are desired. Habitat must be protected, created, or enhanced for the species desired	Generally less than 10 years
Endangered species (alive)	Critical habitat must be protected, enhanced, or created	Preservation of habitat requires no time, creation of habitat may take a few years to hundreds of years
Water	Control sources of pollution, some modification of quantity possible by manipulating vegetative cover	Generally less than 10 years unless the hydrologic balance has been drastically disturbed
Timber	Replanting unforested areas, silvicultural practices to increase growth rates	Thirty to over a hundred years
Landscape esthetics	Varies with values and objectives, in relation to timber harvest generally involves restriction of harvest in areas of high recreation use, reduction in size of clear cuts	Tens to hundreds of years (higher end to establish wildernesslike esthetics
Wilderness	Withdrawal from other consumptive uses, restriction of use intensity to preserve wilderness condition	Usually hundreds of years to reestablish once wilderness environment has been disturbed
Soils and watersheds	Protection and preservation	Thousands to tens of thousands of years to reestablish equilibrium after drastic disturbance
Minerals	Control rate and efficiency of use	Millions to hundreds of millions of years
Endangered species (extinct)	Generally none, unless possible to reestablish species through genetic breeding	New species may evolve to replace niche left by extinct species, but the loss of the gene pool is usually irreversible

SOURCE: Office of Technology Assessment.

Photo credit: U.S. Forest Service

Tree plantation can help prevent erosion while also providing landowners with income. This farm was badly gullied by erosion before loblolly pine plantings were begun in the mid-1940's on the hillsides. By the early 1960's, the owners were able to harvest some of the pine for pulpwood applied in some other Federal, State, and local forest systems. The Forest Service's RPA assessments call for increased production of both timber and nontimber resources from national forest lands.

Lands owned by the forest products industry and by some States are managed primarily to produce timber, but other objectives such as wildlife and recreation also may be included. Multiple use resource management is less often a goal of private nonindustrial landowners, but they too have numerous opportunities for it. For example, less than 15 percent of eastern forestland with grazing potential is now being grazed, according to the SCS. The recreational potential of private acreage also is far greater than is currently realized. In a limited number of cases, forests can serve pollution control objectives, such as in the application of treated sewage sludge to forestland. When properly conducted, sludge applications enhance growth by providing important plant nutrients without appreciable environmental damage or health hazards.

Some forestland functions are difficult to quantify in economic terms. The importance of the forest in hydrologic regimes and in minimizing soil erosion has been understood for over a century. Many of America's most scenic areas are forested. Designated wilderness areas, most of which are on Federal lands, are critical for recreation and scientific

Photo credit: U.S. Forest Service

The esthetic and recreational values of national forests are an important part of forest management. The view is taken in Mt. Hood National Forest in Oregon research and increasingly are being recognized both as a national and global heritage of immeasurable long-term value.

Because of wide variation in site conditions, it is hard to generalize about the nationwide or regionwide effects that increased timber production would have on other forestland values. In the 1980 RPA assessment, the Forest Service introduced a model to show some of these interactions (table 28). An important characteristic of the model is that it permits different assumptions to be used about resource management while quantifying potential effects on other resources. A more refined model is expected to be used in the 1985 assessment. Such efforts, by developing realistic portrayals of future effects on domestic forests of increased timber production, can help decisionmakers understand resource tradeoffs.

Table 28.—Multiresource Interactions in the Southeast Resulting From Meeting Projected Timber and Range Grazing Demands

Item	Units	1977	1985	1995
Projected demands:[a]				
Softwood timber	Billion cubic feet	—	2.42	3.06
Hardwood timber	Billion cubic feet	—	1.01	1.35
Range grazing	Million animal unit months	—	18.10	21.50
Resource use and environmental effects:				
Dispersed recreation use	Percent change from 1977	—	10.1	-4.0
Herbage and browse	Percent change from 1977	—	6.0	16.0
Wild ruminant grazing	Percent change from 1977	—	-0.3	2.0
Water yield	Percent change from 1977	—	0.4	1.0
Sediment	Percent change from 1977	—	89.0	116.0
Storm runoff	Percent change from 1977	—	0.3	0.1
Intensity of land resource used:				
National Forest lands:[b]				
Extensive use[c]	Percent of area	89	77	72
Intensive use[c]	Percent of area	11	23	28
Other Federal lands:				
Extensive use[c]	Percent of area	98	91	89
Intensive use[c]	Percent of area	2	9	11
State and private lands:				
Extensive use[c]	Percent of area	78	70	65
Intensive use[c]	Percent of area	22	30	35

[a] Projected demands as shown in the review draft of the 1980 RPA assessment.

[b] In this multiresource interaction analysis the areas recommended for wilderness or further planning by the RARE II process were considered wilderness.

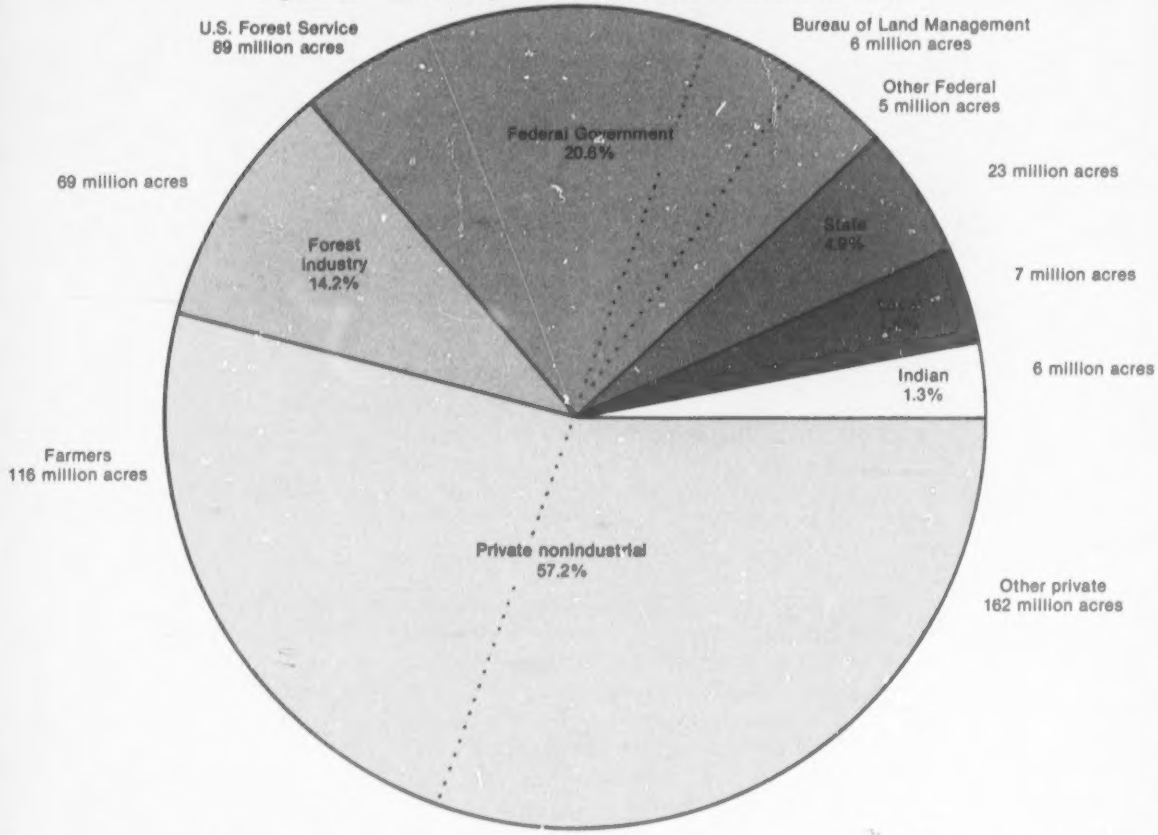
[c] The land resource use is said to be intensive if one or more of the timber, range, or wildlife activities of the resource management options are intensive. Timber activities are defined as intensive if intermediate treatments between regeneration and harvesting are conducted. Range activities are defined as intensive if practices, mainly species conversion, are made to maximize livestock forage production. Wildlife activities are defined as intensive if vegetative manipulation practices are undertaken to improve wildlife habitat. If none of the three activities are intensive, the use is considered extensive.

SOURCE: Adapted from *An Assessment of the Forest and Rangeland Situation in the United States* (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1980), p. 513.

Ownership and Management of Forestland

Trends in ownership have an important bearing on current and prospective uses of forestland. The Forest Service separates forest landowners into three basic categories: **public** (Federal, State, local, and Indian), **forest industry** (corporations or individuals who own or operate a wood-processing facility), and **private nonindustrial forest owners** (farmers, "miscellaneous" individuals, and corporations that are not part of the forest industry). PNIF land comprises 58 percent of all commercial forests; industry lands 14 percent; and public lands the remaining 28 percent (fig. 26).

Figure 26.—Ownership of U.S. Commercial Forestland, 1977



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 121.

Ownership composition varies significantly by region. In the Western United States, Federal and State Governments and the forest industry, which collectively own over 75 percent of the region's forests, dominate. In the Eastern United States, private nonindustrial owners hold most of the forestland, although forest industry holdings are large in Maine and in the South. Federal holdings in the East may be locally important, but constitute only 5 percent of forested areas.

Timber harvest levels among ownership classes are not a function of acres held (table 29). Forest industry lands—14 percent of commercial forests— accounted for an estimated 31 percent of timber harvested in 1976, while other ownerships provided less timber per acre.

Nearly half (47 percent) of all U.S. timber supplies in 1976 came from private nonindustrial lands. In the East, however, PNIFs' contributions to regional timber supplies are far higher. Forest Service projections suggest that the forest products industry will rely increasingly upon these PNIF lands for wood. By 2000, according to the Forest Service, 54 percent of the harvest will come from private nonindustrial sources (fig. 27). This represents more than a 50-percent increase in roundwood supplied from PNIF lands in 24 years.

Publicly Owned Forestland

About 28 percent of commercial forestland is owned or held by Federal, State, or local governments or kept in trust for Indian tribes.

Table 29.—Roundwood Supplies and Acreage by Ownership Class

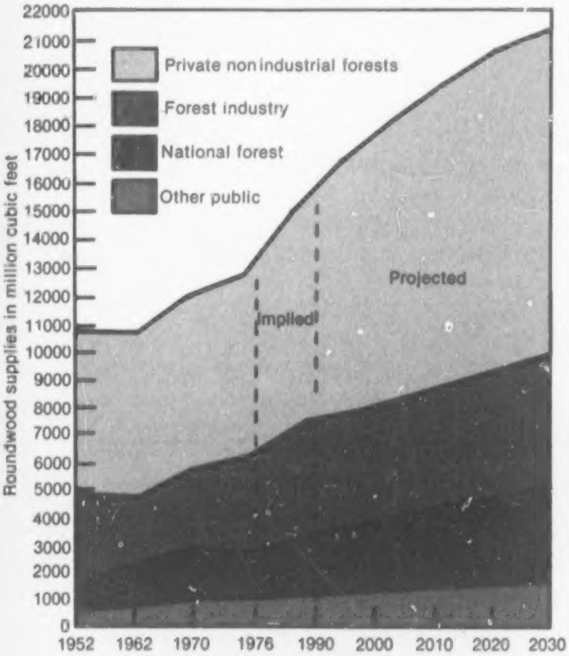
	Million acres[a]		Percent of commercial forest		Volume harvested (million ft³)		Proportion of harvest	
	1976	2000	1976	2000	1976	2000	1976	2000
Forest Service	88.7	80.4	18	17	1,987	2,555	14.9	14.9
Other public	47.0	46.5	10	10	982	1,219	7.7	7.1
Forest industry	68.8	72.2	14	16	3,890	4,141	30.7	24.3
Private nonindustrial forests	278.0	261.9	58	57	5,946	9,169	46.7	53.7
U.S. totals	482.5	461.0	100	100	12,805	17,084	100.0	100.0

NOTE: Survey data in 1981 shows fuelwood consumption to be several times higher than estimated for 1976, but it is not known what proportion of the fuelwood consumed comes from commercial growing stock. Harvest levels cited above for 1976, and projections for 2000, may underestimate historical and projected fuelwood removals.

[a] To convert acres to hectares, multiply by 0.4047.

SOURCES: Adapted from *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D. C.: U.S. Department of Agriculture, Forest Service, 1982), p. 158.

Figure 27.—Roundwood Supplies by Ownership Class; With Base Level Projections to 2030[a]



[a] Supply data for 1952, 1962, 1970, and 1976 are estimates of trend levels of harvests and differ somewhat from Forest Service estimates of actual consumption. Projection year supply data shows volume that would be harvested given the assumptions made by the Forest Service.

SOURCE: Derived from the U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 160.

State and local governments hold about 30 million acres forestland nationwide. In the Great Lakes States, State and county forests are especially prominent, comprising one-fourth of the region's timberlands. Pennsylvania, Alaska, and Washington also own sizable forests. Elsewhere, State and county holdings may be important locally, but comprise a minor fraction of regional timber acreage. Indian lands, about 6 million acres in total, are concentrated in Oregon, Washington, and Arizona.

The Federal Government is by far the most important public owner of forestland. It manages more commercial forestland than any other single entity. Its holdings—nearly 100 million acres in 1977—amount to about one-fifth of the commercial acreage in the country. Ninety-five percent of the Federal holdings are administered by the Forest Service, which manages the National Forest System, and by the Department of the Interior's Bureau of Land Management. Other Federal agencies, such as the Department of Defense, also have commercial forest holdings, mostly located in the East and generally small. In the Western United States, where three-fourths of the Federal commercial timberland is located, Federal holdings comprise 57 percent of the region's commercial acreage.

National Forests

Most of the National Forest System, administered by the Forest Service, is composed of lands reserved by Congress from the original public domain. Other portions, primarily in the East, were acquired by purchase, exchange or donation. Only about half of the land in national forests is commercial forestland. The rest is rangeland, grassland, nonproductive forests, and lands closed to timber production. Some national forest land has been closed to timber production by Congress through wilderness designation, and other land has been deferred pending such designation. Some land also is administratively closed for endangered species habitat or recreation or because it is deemed "unsuitable" (see box G).

In March 1983, the Reagan administration stated that about 6 million acres of national forest land were being considered for possible sale as part of its asset management program.[18] Further study of these parcels was announced; actual sale may require congressional approval. Most of the tracts were in isolated ownerships, checkerboard patterns, special use permits, and community expansion lands.

In 1977, the National Forest System contained about 89 million acres of commercial forestland or 18 percent of total U.S. commercial timberland. Most of the commercial timberland in national forests is located in the West—41 percent in the Rocky Mountain region and 36 percent in the Pacific coast region. The 23 percent in the East is divided about equally between the North and South.

Several different laws govern Forest Service administration of commercial timberland on national forests. The Multiple Use and Sus-

Box G.—Basic Forest Service Management Principles

Multiple Use—The Multiple Use and Sustained Yield Act of 1960 directs that all resource values be weighed and tradeoffs made in making management decisions. It requires that economic factors be considered but not necessarily control management decisions. Also, management objectives must preserve land productivity. The multiple use concept has proven difficult to implement because Congress did not provide criteria for deciding between conflicting land uses. Lands that are managed primarily for recreation, wilderness, wildlife habitat, or watershed may receive little or no timber management treatment.

Sustained Yield—The principle of sustained yield is closely linked to the principle of multiple use. The Multiple Use and Sustained Yield Act defines it as "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output . . . " This relatively straightforward concept is complicated in practice, because many different levels of sustained yield can be defined for a given tract of land, depending on management intensity and the interval chosen for "periodic output." NFMA reaffirmed the concept of sustained yield (nondeclining even flow) but also authorized the Forest Service to depart from even flow in order to meet "overall multiple use objectives." The act failed, however, to provide clear guidance as to what specific situations justify such departures. Under a 1979 Presidential directive, departures are being assessed on some national forests through acceleration of planning.

Harvesting at the High Point of Forest Growth—NFMA affirmed the Forest Service's existing policy of setting timber rotation age at the point of maximum biological growth of a forest stand (called "culmination of mean annual increment"). Such a policy maximizes the volume of timber that is harvested, but financial maturity (the age at which economic efficiency would dictate harvest) generally comes well before biological maturity. This policy has been criticized by economists and the forest industry as being economically inefficient, but by law it remains a strong influence on the formation of national forest management objectives.

Exclusion of "Unsuitable" Land From Timber Production—NFMA restricts timber harvest on lands that have been identified as unsuitable for timber production based on physical, economic, and "other pertinent factors." It also directs that cutover lands be restocked within 5 years after harvest and sets specific criteria for the choice of cutting method. NFMA further requires that the reforestation backlog—which as of October 1, 1982, had been reduced from 6.1 million acres in 1975 to 413,000 acres—be treated by 1985.

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[18] "6 Million Acres of U.S. Forest Eyed for Sale," *Washington Post,* Mar. 16, 1983, p. A8.

tained Yield Act of 1960 (Public Law 86-517) articulated a congressional policy that national forests should be managed for "outdoor recreation, range, timber, watershed, and wildlife and fish purposes."

The setting of land management objectives for national forests is controlled by RPA and its amendment, the National Forest Management Act (NFMA) of 1976 (Public Law 94-585), under the overall framework of multiple use and sustained yield principles set forth in the 1960 act. RPA requires the assessment of all forest and rangeland renewable resources in the United States on a continuing basis and the preparation of a 50-year renewable resources program. These mandates were intended to help Congress set a forest resource budget.

NFMA requires the preparation of management plans under regulations consistent with congressional guidelines, a lengthy and complicated process. At the regional level, forest plans are developed to establish general management objectives, standards, and guidelines. At the local level, forestland and resource management plans are drawn up for each national forest, using the regional standards and guidelines to develop specific objectives and prescriptions for planning units within the forest. The first round of this new planning process is still underway. As of March 1983, individual plans for 18 out of 121 national forests had been released in draft form; the remainder are scheduled for completion in 1983-84.[19]

Basic management principles set by Congress provide a framework for planning and managing the use of timber and nontimber national forest resources (see box G). Their implementation limits timber management and harvest levels in the interests of meeting other resource management objectives. Harvests on individual national forests generally cannot exceed a level which could be removed "annually in perpetuity on a sustained yield basis." However, temporary exceptions to this policy through "planned departures" are authorized in some cases to achieve sustained yield objectives. In 1979, the Carter administration called for accelerated updating of plans on some national forests to increase sales of mature timber. This process continues today.

The potential for producing more wood per acre of allocated timber production land under Federal laws is substantial. An important limitation to more intensive management, however, is budgetary constraints.

Bureau of Land Management Land

The Bureau of Land Management (BLM) was created in 1946 to administer Federal Government properties that were never disposed into private ownerships or set aside for special uses. Nearly all of these are in the West.

BLM manages 5.8 million acres of commercial timberland. About half of this is original public domain lands. The other half is the so-called "O&C" lands, located in western Oregon. This acreage is the remains of a land grant that was revested by Congress in 1866 when a railroad failed to comply with the terms of its grant. The O&C lands are BLM's most productive and are among the most productive forestlands in the country.

Permanent objectives for BLM-administered lands were not clarified until enactment of the Federal Land Policy and Management Act (FLPMA) of 1976 (Public Law 94-579). FLPMA directs that public lands, only 1 percent of which are forested, be managed on a multiple use, sustained yield basis, but the act does not provide specific objectives for timber resources. O&C lands are administered under FLPMA and the O&C Act of 1937 (50 Stat. 875), which name timber production as the major ownership objective. In the event of conflicting purposes, the O&C Act prevails.

In response to FLPMA's mandate, BLM is preparing Resource Management Plans for each of its management units. These documents will combine in one environmental impact statement, as required by the National Environmental Policy Act of 1969 (Public Law 91-190), both land use allocations and specific guidelines on how lands will be managed. Six factors must be considered in reaching decisions:

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[19] U.S. Department of Agriculture, Forest Service Land Management Planning Staff, personal communication, Washington, D.C., Oct. 14 1982.

1. legislative and Department of the Interior goals,
2. resource demand forecasts,
3. estimated sustained levels of the multiple uses that may be obtained under existing biological and physical conditions and differing management practices,
4. degrees of management intensity which are economically viable,
5. opportunities to resolve public issues, and
6. degree of local dependence on public land resources.

Thus, planning objectives for BLM-administered forestlands, like those for the National Forests, balance many different legislative mandates.

Other Legislative Mandates for Federal Lands

Many other statutes related to environmental protection and the management and use of public lands affect Federal forest management. The National Environmental Policy Act (NEPA), for example, requires preparation of environmental impact statements for Federal actions that may significantly affect the environment, including some forest management activities on Federal lands.

Another example is the Endangered Species Act of 1973 (Public Law 93-205). The act protects endangered species on Federal lands by prohibiting activities that damage their habitats, and some view it as a potential major conflict with timber production on Federal forests. Although about 200 threatened and endangered species are listed by the Federal Government, most have specialized habitats that cover relatively small areas. Only a few species appear to have potential for serious conflict with timber production. The grizzly bear and gray wolf are two of them. The national forests are considered to be of major significance in the recovery of these species, because large portions of their habitat—82 percent or 4,432,920 acres of the gray wolf's, for instance—are on national forest lands. In the Pacific Northwest, efforts to protect the spotted owl may conflict with timber production because this species requires old-growth conifer stands for habitat. In other national forest regions, there may be cases where endangered species protection reduces Federal lands available for timber production, but these areas are likely to be small in relation to total national forest acreage available for harvest.[20]

Another law, the Wilderness Act of 1964 (Public Law 88-577), also has been perceived by timber interests as a threat to future wood supplies. Although the act clearly has resulted in substantial acreage being removed from production, wilderness lands are generally below average in productive potential. There are presently 25.1 million acres in the National Wilderness Preservation System, but only 40 percent of this land (10.2 million acres) is "productive reserved land"— i.e., land that would be called commercial forestland if it had not been withdrawn from timber production. Table 30 shows the average productive potential by Forest Service region of "productive reserved land" included in existing wilderness areas. Only Alaska and the Pacific Southwest have wilderness with high productive potential, and the acreages are relatively small. In four regions, the average productive potential of wilderness areas is less than 50 ft^3/acre/year, which often is considered the minimally acceptable cutoff point for economical timber management.

In recent years, Congress has prohibited the sale of Federal timber to companies who intend to export it prior to processing. It also has prohibited the sale of timber to purchasers who use Federal timber to substitute for exported unprocessed logs from private lands. The rationale for this restriction has been jobs. Congress intended to encourage domestic processing of the raw material to provide employment for U.S. workers, implying that this benefit is yet another objective of Federal forest management.

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[20] As discussed in J. Russell Boulding, *Federal Forests: An Assessment of Their Management, Use, Potential Productivity, and Economic Significance*, OTA contract report, June 1982, p. 5-9.

Table 30.—Regional Distribution of Productive Reserved National Forest Lands in Wilderness and Their Average Productive Potential, 1981

Forest Service region	Productive reserved forest in wilderness (millions of acres)[a]	Average potential production (ft^3/ac/yr)[b]	Regional productive potential average (ft^3/ac/yr)[b]
Northern	2.2	56	—
Rocky Mountain	1.5	43	63.7
Southwestern	0.8	41	—
Intermountain	1.8	40	—
Pacific Southwest	0.4	78	90.8
Pacific Northwest	1.2	42	—
Southern	0.1	59	71.1
Eastern	0.8	56	62.3
Alaska	1.4	109	—
Total	10.2		

[a] To convert acres to hectares, multiply by 0.4047.
[b] To convert ft^3/ac. to cum/hectares, multiply by 0.07.

SOURCE: Compiled by the Wilderness Society, Washington, D.C., from 1981 Forest Service Data.

Forest Industry Lands

The forest industry owns land primarily to produce commercial timber. About 69 million acres were owned by the forest industry in 1977. These lands on the average are naturally more productive than lands in other ownerships, they generally are in larger tracts, and they often are located near mills.

Forest industry landownerhip is highly concentrated. In 1978, the 90 largest firms owned 62 million acres of forestland—91 percent of all industry-held acres.[21] Nearly half (48 percent) of the total was owned by just 17 companies, with the half-dozen largest firms each having holdings the size of Connecticut. Most of the remaining 30,000-plus companies in the lumber or pulp and paper sector either have minor landholdings or none.

In addition to land they actually own, forest products firms lease a substantial amount of private property. Management activities on leased land vary from minimal maintenance to intensive timber management practices. Short-term leases generally involve timber harvesting but not management. Long-term leases, which often do involve management, are an important trend in the South, where nearly 6.7 million acres are leased for 25 years or more.[22] Leasing activities by the forest industry may increase in the future, especially in those areas where large mills require large timbersheds for supplies.

The South contains more than half of the industry's holdings. All but one of the Southern States have at least 1 million acres, and in each of six of these States, the industry owns more than 3 million acres.

In the West, where Federal forestlands dominate, the major forest industry holdings are in Oregon, Washington, and California, with much smaller (1 million acres) but still significant holdings in Idaho and Montana. In the North, Maine alone contains nearly half of the region's industrial forestland. Most of the remaining northern industrial holdings are in the Great Lakes States and in Pennsylvania and New York.

The era of large-scale assembly of new forest industry lands may be over. There are many reasons for this, but possibly the most important is the tremendous increase in land prices in the 25 years following World War II. Although price increases have moderated or declined just recently (1980-82), it still seems unlikely that the forest industry as a whole will embark on major new land acquisition programs in the coming years. In fact, during the 1980-82 recession, forest industry firms have tried to sell several million acres of commercial timberland; this may have been a short-term response to acute cash flow problems brought on by high interest rates and by the economically depressed state of the industry. The Forest Service projects that only about 4.4 million acres of additional industry holdings will be purchased in the next 50 years (table 31). About three-fourths of this increase is projected for the South, much of the remainder is in the North, and a modest increase is expected to occur in the West. The Forest Service projects that most of these purchases will take place before 2000; thereafter, forest industry holdings will begin to decline—chiefly as a result of the disposal of some industry lands in the Pacific Northwest.

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[21] Jay O'Laughlin and Paul V. Ellefson, *New Diversified Entrants Among U.S. Wood Based Companies: A Study of Economic Structure and Corporate Strategy*, Bulletin 541-1982 (St. Paul, Minn.: University of Minnesota Agriculture Experiment Station, 1982), p. 18.

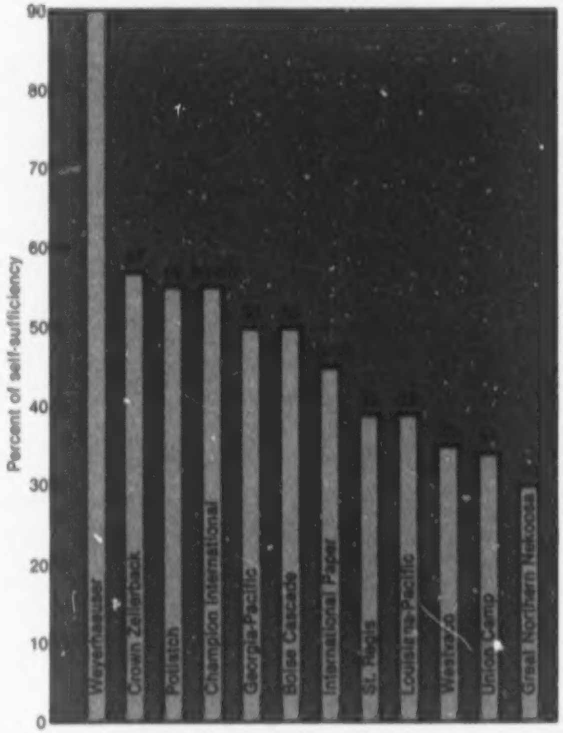
[22] U. S. Department of Agriculture, *The Federal Role in the Conservation and Management of Private Non-industrial Forestlands*, Interagency Committee Report (Washington, D.C.: U.S. Department of Agriculture, 1978), p. 41.

Ownership Objectives

The forest industry's major landowning objective is the production of timber for its mills.[23] For strategic corporate reasons, partial self-sufficiency in timber supply is considered important to those forest products companies that own land. Relatively few firms, however, can rely on their own lands for more than a portion of their timber needs (fig. 28). Most firms are highly dependent on PNIF or public lands to provide much of their wood.

In the past, when old-growth timber was abundant and land prices low, companies acquired land with the simple objective of cutting the trees. Today, however, old-growth supplies have dwindled and land prices have risen sharply, so objectives now center on managing existing holdings for improved production. Potential acquisitions are evaluated for their productive capacity as well as for their existing timber stand.

Figure 28.—Timber Self-Sufficiency of Major Timber Processing Firms



SOURCE: *Forbes*, Dec. 24, 1979, as reproduced in U.S. General Accounting Office, *New Means of Analysis is Required for Policy Decisions Affecting Private Forestry Sector* (Washington, D.C.: U.S. General Accounting Office, 1981), p. 13.

Table 31.—Forest Industry Holdings, 1952-77 (million acres)[a]

	1952	1962	1970	1977	Projected 2030
North	14	13.9	17.4	17.9	18.7
South	32	33.4	35.0	36.2	39.7
West	13.5	14.1	14.5	14.6	14.7
Total United States	59.5	61.5	67.0	68.8	73.1

[a] To convert acres to hectares, multiply by 0.4047.

SOURCE: Brian R. Wall, *Trends in Commercial Timberland Area in the United States by State and Ownership, 1952-1977, With Projections to 2030* (Washington, D.C.: U.S. Government Printing Office, 1981), pp. 15, 18, and 21.

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[23] O'Laughlin and Ellefson, *New Diversified Entrants*, table 5, p. 16.

Rapid population growth and increased demand for outdoor recreation have made some industry land more valuable for uses other than timber production. Firms with large holdings usually have realty divisions or subsidiaries. Forest industry real estate activities were highly publicized in the early 1970's when several firms began to promote recreational home sales and development on their lands. Since the 1974-75 recession, however, the industry's real estate ventures have been relatively conservative. Rural population growth also is increasing the potential for conflict between industry and residential goals. A case study in one Texas county found that local timber companies opened their lands to the public for hunting, in part because of a good neighbor policy but also because of threatened arson or vandalism.[24]

Management of Industrial Lands

Since timber production is the major objective of the forest industry, the prospects for higher output in response to increased demand look very good. Response would be limited, of course, by how profitable it would be to invest in more intensive management. The productive capacity of most industry lands is high, however, and they are generally well-located near processing facilities and contain large tracts capable of capturing "economies of scale" in management.

Management intensity on industrial forestlands apparently is increasing, although significant differences exist among firms and data is limited. According to a review by Jay O'Laughlin and Paul V. Ellefson, those few studies that have been conducted suggest a mixture of management intensity among different industrial size classes. One study of 20 major firms, which together owned almost 40 million acres of timberland in 1969, found that 16 of the firms practiced varying degrees of management. All of them had planting programs, 11 used timber stand improvement, and 13 practiced site preparation. Four of the companies apparently did not practice management even though they each owned more than 1 million acres. Another study of 166 firms in the mid-1970's found that those with holdings of 250,000 acres or more used certain management practices (precommercial and commercial thinning, timber stand improvement, fertilization, site preparation, and genetic improvement) to a greater extent than did firms with smaller holdings, but it found no significant differences between other forest management techniques. This study also found that industrial lands were managed most intensively in the South and Pacific Northwest, and that large tracts were more intensively managed than small ones.[25] Industry planting and direct seeding of harvested land have increased from an average annual rate of about 150,000 acres in 1950 to over 1 million acres per year in the mid- to late-1970's.

Since 1949, about 19 of the 90 largest forest industry firms have merged or been acquired by conglomerates. These 19 companies presently own about 14 percent of the total forest industry land base and account for about 8 percent of wood-based sales in the United States.[26] It has been speculated that these conglomerates may be less inclined toward long-term forest management than traditional forest industry firms, but a recent University of Minnesota report found little ground for such speculation. Based on questionnaires and interviews with several diversified and traditional forest product firms, the study concluded that, ". . . the large diversified firm with a wood-based subsidiary manages its lands no differently than does the traditional wood-based company."[27] In fact, the study found that the diversified firms that were surveyed invested slightly more in forest management on a per-acre basis than did traditional companies. It should be noted, however, that the study was based only on a partial response by firms and that some traditional forest products companies may have been more reluctant to reveal information about management than the new diversified firms.

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[24] Robert C. Healy and James L. Short, *The Market for Rural Land: Trends, Issues and Policies* (Washington, D.C.: Conservation Foundation, 1981), pp. 51-58.

[25] This discussion of industrial forestland management is drawn extensively from *New Diversified Entrants*, pp. 33-35.

[26] Ibid., p. 20.

[27] Ibid., p. 43.

Private Nonindustrial Forest Lands

Private nonindustrial forestland, sometimes termed underproductive, actually makes a major contribution to U.S. wood supplies. About half (46 percent) of all roundwood and 38 percent of sawtimber were harvested from these lands in 1976. While their contribution to national wood production is proportionately smaller compared to the total acres their owners hold—about 58 percent of the commercial forestland or about 278 million acres—this difference is less pronounced when regional markets are considered.

About nine-tenths of PNIF lands are in the East (table 32), where they account for over two-thirds of regional timber supplies. PNIF lands are especially important in the South, which contains more than half of all private nonindustrial land. Because the forest products industry is concentrated more heavily in the South than in the North,[28] the southern PNIF is viewed as a critical part of the national timber supply.

Table 32.—Area of U. S. Commercial Timberland in Private Nonindustrial Forest (PNIF) Ownership by Region (thousands of acres)[a]

	Commercial timberland in PNIF ownership
North	117,715
South	134,070
Rocky Mountains	12,502
Pacific coast	13,695
Total United States	277,982

[a] To convert acres to hectares, multiply by 0.4047.

SOURCE: *An Analysis of the Timber Situation in the United States 1952-2030*, (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1982), pp. 344-349.

In the Pacific coast region, PNIF owners account for less than 20 percent of commercial forestland. The proportion of large timber on these lands is small relative to other ownerships since the old-growth has been cut and most stands are still immature; thus PNIF lands in this region are relatively insignificant in terms of near-term timber resources. About one-fourth of the Rocky Mountain commercial forestland base is in the private nonindustrial category.

Changing Ownership Composition

Information about PNIF owners comes from three major sources—State forest surveys, a nationwide rural landownership survey conducted in 1978 by USDA, and statewide surveys conducted in 11 Northern States by the Forest Service. The Forest Service traditionally divides PNIF landowners into two categories—farmers and "miscellaneous other" (or all those who are not farmers). "Miscellaneous other" represents a cross-section of society, including professionals, retired people, blue collar workers, and nonwood-based corporations.

State forest surveys over the last three decades have shown a very rapid transfer of land from farm to miscellaneous ownership. In 1952, about 58 percent of all PNIF acreage was in farm ownership and 42 percent was in miscellaneous other (table 33). In 1977, the situation was exactly the reverse—42 percent was in farm ownership and 58 percent were in miscellaneous other. More than 60 percent of the decline in farm forestland occurred in the South and most of the rest occurred in the North.

Table 33.—Change in Farm and "Miscellaneous Other" Ownership: 1952-77 (millions of acres)[a]

	1952		1962		1970		1977	
	Number of acres	Percent of total	Number of acres	Percent of total	Number of acres	Percent of total	Number of acres	Percent of total
Farm	172	58	145	48	125	44	116	42
Miscellaneous other	124	42	159	52	163	56	162	58
Total	296	100	304	100	287	100	288	100

[a] To convert acres to hectares, multiply by 0.4047.

SOURCE: Derived from *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1982), p. 349.

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[28] *An Analysis of the Timber Situation*, op. cit., p. 109.

The implications of this transfer in ownership for timber harvesting and management are unclear. Nonfarm owners sometimes are considered to be less interested in harvesting timber than are farmers and more interested in amenity values. Many of the new owners, however, may be investors able to provide capital for timber management if it is profitable. Some of the PNIF land is owned by nonwood-based corporations, which also may be in favorable positions to undertake management activities (see box H).

Box H.—Forestland Holdings of Nonwood-Based Corporations

Nonwood-based corporations own substantial forest acreage but do not operate wood processing facilities.

Forest Service landownership surveys in 11 Northeastern and Middle Atlantic States provide the best data about these corporate holdings. In the surveyed States, about 6.7 million acres are owned by nonwood-based companies—nearly twice as much land as is owned by the forest industry. (This excludes the major forest industry holdings of Maine, where a survey is not yet complete.) In other surveys, five Southeastern States show a total of 7.4 million acres owned by such firms—about half as much as forest industry holdings in those States.[29] In California, just nine nonwood-based corporations are said to hold 30 percent of all PNIF land.[30] In western Oregon, about 15 percent of the PNIF lands are owned by such firms, and roughly half of this land is in parcels of 5,000 acres or more, according to a recent Forest Service study.[31]

National information on nonwood-based corporate holdings is imprecise. The Forest Service study, *The Private Forest Land Owners of the United States*, identified 89.5 million acres of forestland as being in all categories of corporate ownership—21.8 million acres above estimated forest industry holdings for 1977. This figure is an inexact estimate of nonwood-based corporate holdings, because the landownership survey and forest industry data were derived from different data series and some of the forest industry data is out-of-date.

National information about the kinds of companies involved also is imprecise. Mining and energy corporations may own large quantities of forestland, but information is fragmentary. While it is known, for example, that 21 such firms own at least 3 million acres of land and lease far more private land,[32] the proportion of these holdings that is forested is unknown.

The extent of forestland owned by real estate firms is not available nationwide, but it may be substantial, judging from the Northeast and Middle Atlantic landownership surveys.[33] In Maryland, realty firms held 32 percent of all corporate forestland—more than forest industry holdings in that State. In Pennsylvania, 13 percent of all corporate forestland is owned by real estate firms. Sports and recreation clubs, churches, and other nonprofit organizations hold a significant amount of private forests. About 5 percent of Pennsylvania's private forestland, for example, is owned by hunting and fishing clubs.

Recently banks, investment firms, and other financial institutions have become involved in private forestland management, with some firms offering limited partnerships in these ventures. The trend is too recent to appraise fully, but it is potentially important as a means for channeling capital into PNIF management.

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[29] Information provided by the USDA Forest Service Southeastern Forest Experiment Station.

[30] Cited in Marion Clawson, *The Economics of U.S. Non-Industrial Private Forests*, Research Paper R-14 (Washington, D.C.: Resources for the Future 1979), p. 24.

[31] Donald R. Gedney, *Characteristics of Private Timberland Ownership in Western Oregon*, draft manuscript (Portland, Oreg.: Pacific Northwest Forest and Rangeland Experiment Station), p. 32.

[32] Douglas G. Lewis, *Corporate Landholdings: An Inquiry Into a Data Source* (Springfield, Va.: National Technical Information Service, 1976).

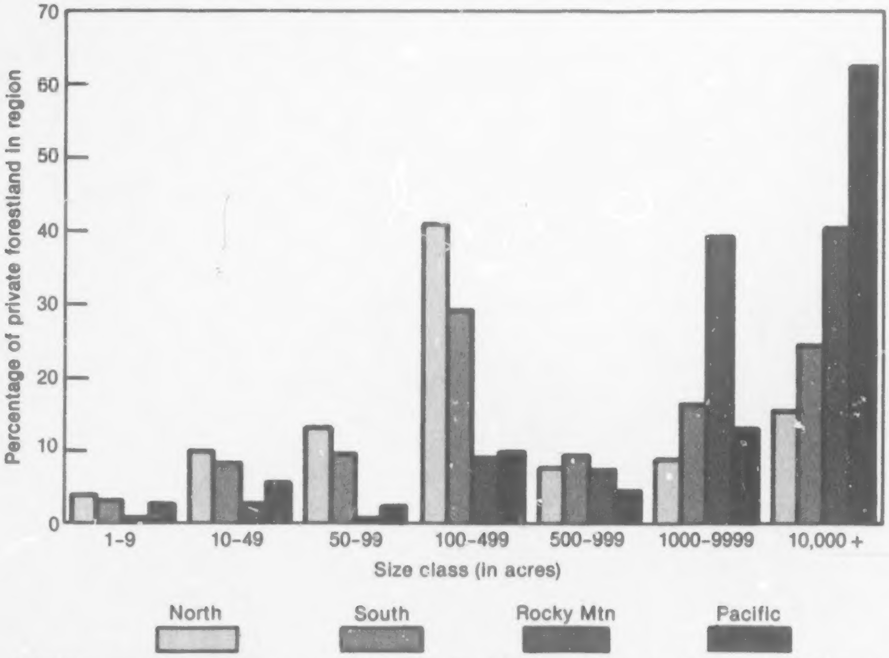
[33] Data on real estate firm holdings are taken from USDA Forest Service surveys of landownership in the Northeastern and Middle Atlantic States conducted during the last decade by the Northeastern Forest Rangeland Experiment Station, Broomall, Pa. Separate reports are available for each of the surveyed States.

More detailed national and regional information about private forest owners is available through a U.S. rural landownership survey that USDA conducted in 1978. Although the survey did not specifically ask questions about forestland, Forest Service analysts were able to construct from the survey data the first nationwide statistical profile of private forest owners in 25 years. The profile is entitled *The Private Forest Landowners of the United States.*[34] In addition, Forest Service analysts have conducted in-depth forest land ownership surveys in the Northeastern and Middle Atlantic States.

The national survey provides data about owners, including their numbers, acres held, occupation, educational level, and other factors relevent to assessment of timber management. It was based on 11,000 respondents. The survey does not distinguish between forest industry owners and PNIF owners—an important qualification, since forest industry holdings account for 69 million acres of forestland.

The national survey provides general information about the size of individual holdings. The overwhelming majority of the 7 million owners of private forestland held less than 10 acres apiece, but these holdings collectively comprised only a small proportion of the land base (fig. 29). Four-fifths of the private forestland is held by people or corporations who own 100 acres or more. Although some individuals own enormous tracts of forestland, most of it that is in the 10,000-acre-plus category shown in figure 29 presumably belongs to the forest products industry or other large corporations.

Figure 29.—Acres of Private Forest Land Ownership Units by Size Class and Region, 1978



SOURCE: Thomas W. Birch, D. C. Lewis, and H. F. Kaiser, *The Private Forestland Owners of the United States*, USDA Forest Service Technical Bulletin (Washington, D.C.: U.S. Government Printing Office, 1982), p. 36.

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[34] Thomas W. Birch, Douglas G. Lewis, and Fred H. Kaiser, *The Private Forestland Owners of the United States*, Forest Service Resource Bulletin WO-1 (Washington, D.C.: U.S. Government Printing Office, 1982).

It is clear from the national data that most U.S. forestland is in large enough holdings for efficient commercial harvesting and management. However, some observers are concerned that parcellation (division of land without development) may be effectively reducing the acreage available for timber production. Adequate historical data is not available to determine whether the proportion of forestland in small tracts has increased nationwide. Most case studies in specific rural areas suggest that parcellation has been most intense on tracts that were small to begin with.[35] Hence, forestland in holdings of 100 acres or less (about 20 percent of the private acreage according to the 1978 survey) are probably most likely to be subject to parcellation. Still, in some areas, consolidation of land into larger parcels may have occurred. Closer monitoring of parcellation will be needed to identify national trends clearly.

Ownership Objectives

Many local surveys have been conducted which reveal landowner objectives, but the results of such surveys cannot be combined or compared with statistical accuracy because of different methodologies. Nevertheless, some generalizations can be made about their findings:

- PNIF ownership objectives vary widely both within and among regions. Owners in the Southeast appear to be more interested in timber production than those in the North, who are more interested in recreational and other nontimber uses. Lack of markets in the North may explain part of this difference.
- PNIF owners who harvest timber tend to have larger parcels of forestland than those who do not; hence, the proportion of land held by owners with timber production objectives tends to be high relative to their numbers, and the proportion with recreational objectives tends to be low relative to their numbers.[36]

Limited regional data on ownership objectives is available for both the Northeast and Southeast. In a survey of PNIF owners in the Southeast, 62 percent reported that timber management is very important on the land they own, but fewer owners (54 percent) actually named timber growing as an important ownership objective. Much of the land was not specifically acquired for timber management, however, and is held for reasons in addition to timber production. For example, over half of the owners indicated that they had inherited their land and that a highly important reason for owning it was to pass it on to their heirs.[37]

In the Northeast, nearly half of the owners have forestland simply because it is part of their farm or residence or because they derive esthetic enjoyment from it. These owners, however, hold only about one-third of the region's PNIF acreage. About 10 percent of the PNIF lands in the Northeast are held for recreational purposes and 14.5 percent for investment reasons. Less than 2 percent of the owners report that they hold land for timber production, but they own approximately 15 percent of the acreage.[38]

Forest Service landownership surveys in the Northeastern and Middle Atlantic States found that less than 1 percent of the harvests on PNIF lands were conducted for timber stand improvement purposes. Only 9 percent of the owners have ever received any kind of forestry assistance.[39]

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[35] Healy and Short, *Market for Rural Land,* op. cit., p. 22.

[36] Jack P. Royer, *A Report to the Forest Productivity Committee of the Forest Industries Councel Highlighting the Findings of a Review of Non-Industrial Private Forest Owner Surveys, and Assessing the Usefulness of Data from Past Surveys in Evaluating Alternative Proposals for Improving Forest Productivity,* unpublished manuscript, Center for Resource and Environmental Policy Research (Durham, N.C.: Duke University, School of Forestry and Environmental Studies, 1979), p. 16.

[37] Unpublished results of the 1981 Reforestation Survey conducted by U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board.

[38] Neal P. Kingsley, "The Northeastern Forest Landownership Study," in Jack P. Royer and Frank J. Convery, eds., *Non-Industrial Private Forests: Data and Information Needs Conference Proceedings* (Durham, N.C.: Duke University School of Forestry and Environmental Studies, April 1981), p. 90.

Similar but more explicit findings come from the Southeast. For instance, on lands from which pine has been cut, the most common harvest method was partial cutting, a practice resulting in site conditions that are suboptimal for pine regeneration. On 80 percent of the harvested lands, no site preparation practices (readying the land for reforestation) were carried out, and 65 percent of the lands were not planted or seeded with pine but left to reforest themselves naturally. As a result, these lands probably will be restocked eventually with hardwood or mixed pine/hardwood stands of relatively low timber value. Eighty percent of the lands in the sample were not covered by forest management plans.[40]

These statistics would be more illustrative if they could be compared with similar data for other ownerships, but such information is not available. They do suggest, however, that PNIF owners as a whole in the Southeast are not taking active steps to perpetuate their supplies of pine.

Factors Affecting Implementation of Intensive Timber Management

Timber growth trends, while favorable, could be increased dramatically through intensified management. Net annual growth on all commercial forestland in the United States in 1976 was about 60 percent of the estimated productive potential if all forests were in well-stocked natural stands. Among regions, the Pacific coast has the highest productive potential (97 ft³/year), although actual growth in 1976 reached only about half that. The South has the next highest potential (77.3 ft³/year), with actual growth the highest for any region (74 percent of potential) (table 34 and fig. 30).

Table 34.—Average Net Annual and Potential[a] Growth per Acre in the United States, by Ownership and Section, 1976 (cubic feet)

Item	All ownerships	National Forest	Other public	Forest industry	Farmer and other private
North					
Current	35	43	36	44	33
Potential	66	63	59	74	66
South					
Current	57	57	54	60	56
Potential	77	71	71	83	77
Rocky Mountain					
Current	29	30	25	50	25
Potential	60	64	55	74	51
Pacific coast					
Current	49	30	53	80	62
Potential	97	91	88	119	99
United States					
Current	45	35	42	59	45
Potential	74	74	65	87	72

[a] Potential growth is defined as the average net growth attainable in fully stocked natural stands. Much higher growth can be attained in intensively managed stands.

SOURCE: *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1982), p. 137.

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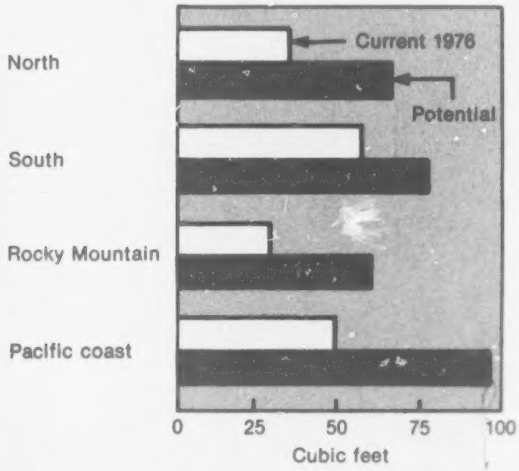
[39] Kingsley, "Northeastern Forest Landownership Study," op. cit., pp. 91-92.

[40] Unpublished results of the 1981 Reforestation Survey.

Figure 30.—Current and Potential Net Annual Growth per Acre by Section[a]



[a]Potential growth is defined as the average net growth attainable in fully stocked natural stands. Much higher growth can be attained in intensively managed stands.

SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 137.

Historical evidence suggests that dramatic gains in productivity could be made with modest improvements in the intensity of timber management practices.[41] The rate of improvement would depend on two factors—the time required for wood output to be increased as a result of management investments and the rate at which landowners are willing and economically able to intensify forest management. Because of the lag time between management investments and resulting yields, the full impact of intensification measures begun immediately would not be attained nationwide until after 2000 and probably would not peak until after 2030.

Through cooperative Federal, State, and private programs, most U.S. forestland is now managed extensively to control wildfire and limit damage from insects and disease. About 1.4 billion acres of forest, rangeland, and other rural land are now under organized fire protection. The total area of commercial forestland burned by wildfire has decreased significantly since the early 1950's, in part because more land is now protected. Successful control and suppression of wildfire almost certainly has contributed much to improved growth trends on private nonindustrial lands.

Intensive timber management is applied currently on only a small portion of U.S. forestland, but apparently its use is spreading. Most of the practices now applied involve planting trees or seeding harvested areas with commercially desirable species, primarily softwoods, and intermediate stand treatments, primarily precommercial thinnings and release/weeding (see ch. V for a discussion of management practices).

Artificial regeneration of stands has increased steadily on forest industry lands since the early 1950's as well as on public lands, although to a lesser extent. Planting of PNIF lands reached an all time high in the late 1950's and the 1960's as a direct result of the Federal soil bank program, now defunct, which paid farmers to plant trees on cropland to conserve soil and reduce grain surpluses. Intermediate stand treatments on all ownerships reached a high point in 1968, having fallen off subsequently. Figure 31 and table 35 show estimated annual acreage treated by ownership and region. Current levels of tree planting and seeding on all PNIF lands are less than half the levels of the soil bank era.

The first systematic evaluation of the possible effects of cost-effective management was completed in 1980 by the Forest Productivity Project of the Forest Industries Council. This project developed detailed estimates of the economic potential for increasing timber growth, by ownership, in 25 States that contain about 80 percent of the commercial forests in the United States.

The Forest Industries Council study estimated that profitable management opportunities could be undertaken on 139 million acres of commercial forestland in these 25 States if the minimum rate of return was 10 percent. The Forest Service, using a 4 percent return-on-investment criteria, estimated that 168

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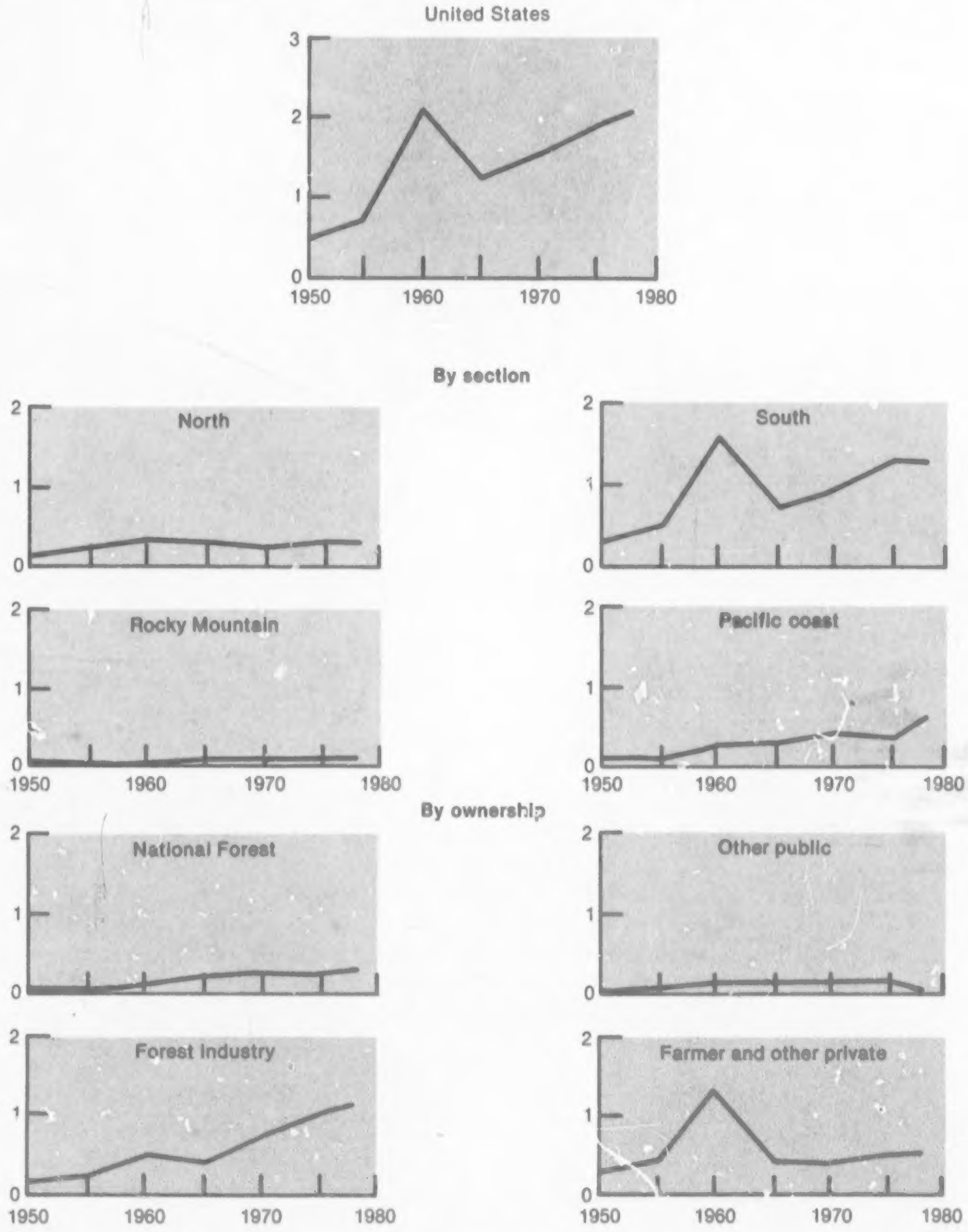
[41]R. Fisher, "Productivity in Florida's Third Forest," *Journal of Forestry*, vol. 79, 1981, pp. 613-615.

Figure 31.—Area Planted and Direct-Seeded, 1950-78 (million acres)



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Government Printing Office, 1982), p. 229.

Table 35.—Area Planted and Direct-Seeded in the United States, by Section and Ownership, 1950-78 (thousand acres)

		Section				Ownership			
Year	United States	North	South	Rocky Mountain	Pacific coast	National Forest	Other public	Forest industry	Farmer and other private
1950	488	137	285	15	52	45	54	153	237
1951	453	164	245	15	29	46	49	106	253
1952	520	191	250	15	63	50	67	143	260
1953	710	212	420	17	60	53	89	217	352
1954	808	236	506	17	49	54	70	265	419
1955	779	242	482	5	51	56	72	239	413
1956	886	235	574	7	70	61	84	257	484
1957	1,138	258	782	7	91	85	86	311	657
1958	1,533	285	1,080	7	161	89	119	370	955
1959	2,117	283	1,642	13	179	112	123	417	1,465
1960	2,100	308	1,567	14	212	134	130	521	1,315
1961	1,761	302	1,205	18	235	163	140	588	870
1962	1,366	270	816	27	253	198	151	443	573
1963	1,325	270	798	37	221	221	151	467	486
1964	1,313	269	756	42	246	208	161	485	460
1965	1,285	268	708	64	245	233	136	455	461
1966	1,281	265	696	69	251	237	144	475	425
1967	1,373	245	769	65	294	257	132	527	457
1968	1,439	281	795	69	294	269	128	604	437
1969	1,431	250	808	73	300	257	127	681	367
1970	1,577	225	925	70	357	261	131	763	422
1971	1,667	271	1,002	84	310	267	124	895	381
1972	1,647	211	1,014	68	354	268	114	828	436
1973	1,721	195	1,051	81	394	299	123	879	420
1974	1,576	168	1,037	65	306	272	116	836	352
1975	1,900	249	1,269	73	309	293	138	1,059	410
1976	1,858	184	1,172	76	426	292	135	1,040	391
1977	1,942	160	1,301	57	424	257	120	1,138	427
1978	2,072	233	1,245	74	520	296	124	1,145	507

SOURCE: *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1982), p. 231.

million acres in the same 25 States presented "economic opportunities" for management (national forest land was excluded). Capital requirements for taking advantage of all of the management opportunities identified in the two studies would be high, both in aggregate ($10 billion to $15 billion nationwide) and on a per-acre basis.[42]

Most of the opportunities identified involved establishing and maintaining softwood species in the East, primarily on private nonindustrial forestlands and often at a cost of more than $100 per acre (table 36). Less costly management opportunities (such as management of existing hardwood stands to optimize growth) received less attention. Planting softwoods on idle fields also is less expensive than stand regeneration on harvested sites, but this too was not emphasized in the two studies, which were conducted prior to 1983 cropland set-asides.

Many factors are believed to influence private landowners' management decisions, and the most important ones seem to be closely related to potential return on the management dollar.[43] Other factors such as tract size and ownership tenure also are believed to be influential, especially on PNIF ownerships. In addition, there is evidence that timber manage-

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[42] *Analysis of the Timber Situation*, op. cit., p. 248; and Forestries Industry Council, Forest Productivity Report, p. 46.

[43] U.S. Department of Agriculture, Forest Service, *Economic Opportunities to Increase Softwood Production on Forest Lands*, vol. II (Investments) (Washington, D.C.: USDA Forest Service, 1981).

Table 36.—Costs per Acre of Achieving Management Opportunities Identified by the Forest Service and the Forest Industry Council

	Acres (million)	Total cost (million dollars)	Per acre (cost)
Forest Service:			
Reforestation/stand conversion	121.5	$13,525	$111.30
Stocking control	46.7	1,569	33.60
Forest Industry Council:			
Harvest and regeneration	48.2	4,072	84.50
Stand regeneration	16.4	1,872	114.15
Intermediate stand treatment	38.3	756	19.74
Stand conversion	33.3	3,353	100.69
Plant idle cropland	2.6	81	31.15

SOURCES: Forest Industries Council, *Forest Productivity Report* (Washington, D.C.: National Forest Products Association, 1980); *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D.C.: U.S. Department of Agriculture, Forest Service, 1982).

ment costs have been rising faster than inflation since the late 1960's.[44]

Markets

Uncertainty about future timber markets is perhaps the single greatest deterrent to intensified timber management, since investments need to be made decades in advance of harvest. Limited markets are an especially important constraint on private nonindustrial forests of the North, where the majority of stands support low-grade hardwood stands that historically have been in low demand. New manufacturing processes (such as waferboard plants) have improved markets for such materials in some areas. Expanded hardwood markets, particularly opportunities to sell lower grade, small-size hardwood timber, could stimulate investment in the conversion of less profitable hardwood stands to more valuable softwoods or could lead to improved hardwood management. Increased fuelwood consumption also could encourage such stand improvements if properly undertaken. Since only a small percentage of fuelwood harvesters seek professional advice, fuelwood removals probably are not improving existing stands appreciably.

Stumpage Prices and Market Structure

PNIF owners respond to increases in stumpage prices by making more of their timber available for harvest.[45] [46] [47] Seventy-three percent of PNIF owners surveyed in the Southeast said that they harvested their timber because they were offered a good price, while the second most important reason was that the timber had reached maturity.[48]

Stumpage prices also influence the propensity of landowners to **manage** their timber, although the effect is less clear. Among PNIF owners in general, a poor market usually is not considered a serious land management problem.[49] However, landowners who see timber production as an important priority respond differently. For example, nonindustrial members of the American Tree Farm System (an industry-sponsored program providing recognition and information to landowners) said low stumpage prices more often than any other variable discouraged them from managing their tree farms more intensively.[50] [51]

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[44] J. Moak, W. Watson, and P. Van Deusen, "Costs and Cost Trends for Forestry Practices in the South," *Forest Farmer Manual*, 1981, pp. 58-63.

[45] Clark S. Binkley, *Timber Supply From Private Non-Industrial Forests, A Microeconomic Analysis of Landowner Behavior*, Bulletin No. 92 (New Haven, Conn.: Yale University, 1981), p. 78.

[46] Roger A. Sedjo and David M. Ostermeier, *Policy Alternatives for Non-Industrial Private Forests*, report of the Workshop on Policy Alternatives for Non-Industrial Private Forests (Washington, D.C.: Society of American Foresters and Resources for the Future, 1978), p. 22.

[47] Clawson, *The Economics of U.S. Nonindustrial Private Forests*, op. cit., p. 187.

[48] Unpublished results of the 1981 Reforestation Survey.

[49] Stoneland Research, "A Study of Private Woodland Ownership in the U.S.," report prepared for American Forest Institute, Washington, D.C., September 1974, p. 11.

[50] American Forest Institute, "Profile of a Tree Farmer," *Tree Farm News*, February 1973, p. 4.

[51] American Forest Institute, "Tree Farm Survey Yields Interesting Data," *Tree Farm News*, summer 1979, p. 3.

PNIF owners in many areas are at a disadvantage in the marketplace because there are relatively few timber buyers. Because of the high ratio of transportation cost to wood value, markets for many tree species and grades of logs are highly localized and may be monopolistic in some respects, often with only one or two purchasers.

Information

PNIF owners often know little about current wood prices, volume estimation techniques, and other aspects of stumpage sales. Thus, many owners have little chance or ability to influence the price they receive for their wood other than electing not to sell. PNIF owners in some areas are seeking more professional assistance and getting better prices as a result,[52] but they are exceptions to the rule.

In addition, owners also may not know enough about potential yields, market characteristics, and timber prices to make good decisions about investing in intensive forest management. Computerized information programs may be an important solution to this problem. The Tennessee Valley Authority (TVA), for example, has developed a software program usable in personal computers that can facilitate timber management decisions (see box I). TVA also is training consulting foresters as part of an outreach effort to expand the use of this tool. Plans by USDA to place computers in county extension offices could broaden the use of such systems.

Length of Ownership

The private nonindustrial forest owner typically owns a parcel of land for a relatively short time. According to the Forest Service report, *The Private Forest Land Owners of the United States,* more than one-fifth of all private forests were acquired by the present owner between 1970 and 1978, while another 20 percent were acquired between 1960 and 1969. In contrast, only 27 percent of the commercial forest area was owned by the present owner for at least 30 years.[53] These estimates include forest industry land, which tends to be held for long periods of time. Transfer of ownership on PNIF lands, therefore, may be more rapid.

Tenure may be slightly longer for lands whose owners name timber production as a major objective, but the difference does not appear to be significant. PNIF owners as a whole acquired their land somewhat more recently than did members of the American Tree Farm System, according to one survey, but 24 percent of American tree farmers still have owned their property less than 10 years.[54]

Short tenures may have a beneficial effect on timber harvest, since owners who are reluctant to harvest soon may be replaced by new owners with new objectives. However, the rapid transfer of forest real estate from one owner to another may complicate efforts to increase the intensity of PNIF management. Most private forestland is held in a single ownership for less than 30 years—the minimum amount of time required even in the South for a stand to reach maturity. It is uncertain whether new owners in general continue management efforts begun by the prior owner.

Tract Size

Various studies show that owner inclination to harvest timber correlates with parcel size. The larger the holding, the more likely it is that the owner will harvest timber from it. According to one researcher, "A shift in the distribution of parcel size to small holdings will, all else equal, lead to less timber supplied."[55] Even when owners of small parcels want to harvest, small-scale logging may be unattractive to large buyers because of the high cost of moving equipment from one logging site to the next. Cooperative management approaches and small-scale machinery can alleviate this problem.

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[52] Personal communication with J. E. Carothers, Louisiana Tech University, Aug. 2, 1982.

[53] Birch, Lewis, and Kaiser, *The Private Forestland Owners of the United States,* op. cit., p. 38.

[54] American Forest Institute, "Profile of a Tree Farmer," op. cit.

[55] Binkley, *Timber Supply From Private Non-Industrial Forests,* op. cit., p. 79.

Box I.—Information Technology and Forest Management

Computer technology can assist forest managers in several ways through easy storage and rapid retrieval of data, development of management strategies for forestland at various geographic scales, and education and training for foresters, landowners, and decisionmakers.

Computerized information systems have been used by the Forest Service in developing individual forest plans (FORPLAN) as well as in modeling long-range forest needs. The Forest Information Retrieval System (FIR) administered by the Southeastern Forest Experiment Station has for many years provided landowners, industry, and government with easily retrieved, low-cost data at the local, State, and regional levels. The system is commercial and users pay for information retrieved.

With the advent of the microcomputer, personal computers, and associated software programs, computers may now facilitate PNIF management operations. Several forest management software programs now are commercially available. One of the leaders in the development and application of computer technology to forest management is TVA, a public corporation established by the Federal Government in 1936. TVA has developed a software program (WOODPLAN) that combines forest management and business administration that can be used in personal computers.

WOODPLAN programs now available permit users to process timber inventory data into standard stock tables, to forecast yields according to alternative management strategies, and to predict potential lumber yields and corresponding value based on current prices. Financial analysis programs, as well as a "caretaker program" which will store, retrieve, and process information for clients of consulting foresters, facilitate management decisions.

The WOODPLAN program plays an important role in an innovative cooperative effort by TVA, the Forest Service, and the Association of Consulting Foresters to establish self-employed consulting foresters in the region. About 10 consulting foresters have been set up in business since the program was established. TVA presently guarantees work to these foresters during their first 3 years of business to help them get started.

Distribution of the WOODPLAN program has been facilitated through the establishment of Forest Service and State forestry agency computer terminals in central locations in several States. TVA intends to charge for the program in time. The program is offered by at least one commercial firm.

National and regional data comparing management intensities by tract size is not available. However, a similar relationship probably exists. Owners of smaller tracts probably are less likely to manage their land than owners of larger tracts, although there is no data to support this hypothesis. Management of small tracts often is relatively more expensive than large tracts, because it lacks economies of scale. The Forest Service estimates that the per-acre cost of site preparation and planting, precommercial thinning, and removal of trees can be two to five times higher on a 10-acre parcel than on a 160-acre parcel.[56]

Financial Considerations

The peculiar economics of PNIF management often have been singled out as a major roadblock to improved productivity. Specifically, investment requirements or costs of management often are high—as much as $100 to $200 per acre for stand establishment—and cash returns cannot be expected for at least 15 years. This lack of immediate or regular income may discourage PNIF owners, especially those who may not be able to realize a return within their lifetimes. In addition, investments in timber management are illiquid and risky due to potential damage from fire, insects, and disease.

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[56] U. S. Department of Agriculture, *The Federal Role in the Conservation and Management of Private Nonindustrial Forestlands*, op. cit., p. 20.

Also, capital sometimes has not been readily available for PNIF management, but this dearth may be improving as forestland becomes more valuable. Although data on forestland prices is fragmentary, anecdotal evidence suggests that in many areas forest prices increased even more rapidly than farm prices, which rose 900 percent between 1950 and 1977 before tapering off recently.[57]

Increased land values, coupled with financial incentives (such as low-rate long-term loans with no payback penalty offered to PNIF landowners by Federal Land Banks) permit landowners to use their timberlands for collateral. Federal, and in many cases State, tax codes also give preferential treatment to timber acreage. In addition, limited assistance has been offered to PNIF owners through Federal programs such as the Agricultural Conservation Program and the Forestry Incentives Program, although funding for these programs currently is uncertain.

Insurance companies, banks, and other commercial investors are showing interest in owning and managing PNIF lands, especially in the South.[58] The E.F. Hutton Group, which has acquired, managed, and sold timber in the Southeast since 1979, bought 40,000 acres of southern forestland for commercial management in 1981. The First National Bank of Atlanta's "Collective Timberland Fund" is an intermediary for pension funds and for other investors in managed commercial forestlands. Since these companies do not operate mills, they are not classified as part of the forest products industry.

Federal and State Programs for Private Forestland Management

Federal and State tax policies offer preferential treatment to timberland owners. Federal tax incentives that make timber management more attractive to private investors include the capital gains treatment of timber income, the deductibility of some reforestation costs, the preferential valuation of forestland for estate tax purposes, and the deductibility of timber losses (see box J). Many State governments also provide preferential estate tax treatment and have established preferential assessment of forestland for property tax purposes.

The Federal provision allowing capital gains treatment of timber income entails a greater subsidy to timberland owners than all other Federal programs combined, but does not require that tax savings be used for management activities. Although the favorable tax treatment of timber income probably has encouraged management intensification, its direct effect on investments is difficult to establish, due to their long-term nature and many other factors. Another Federal tax provision, adopted in 1980, allows a deduction for reforestation expenses, up to a maximum of $10,000 annually under certain circumstances.

Several Federal programs to provide information, technical help, and direct cost-sharing assistance to private landowners have been established over the last 50 years. These programs are administered by several USDA agencies besides the Forest Service, including the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, and the Cooperative Extension Service. Most funds go through the Forest Service to State forestry agencies for subsequent dispersal, although some USDA agencies administer forestland assistance through general agriculture programs.

The most important cost-sharing program is the Forestry Incentives Program (FIP), which

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[57] Healy and Short, *Market for Rural Land*, op. cit., p. 9.

[58] See, for example, E.F. Hutton & Co., Inc. *Hutton Southern Timber Partner I: Prospectus*, Oct. 30, 1981; and The First National Bank of Atlanta, *Timberland, A Growing Investment From the Ground Up*, May 1, 1981.

Box J.—Federal Tax Incentives to Timberland Owners

Capital Gains Treatment of Timber Income—Under the current IRS Code, gains on the sale of timber may be treated as capital gains rather than as ordinary income—a provision favored by the forest products industry and timberland owners since capital gains are taxed at a lower rate than ordinary income. Capital gains treatment makes timber growing more lucrative, although there is no requirement that owners spend tax savings on management investments. By one estimate, funds available to one subsector of the forest products industry for investment in timberlands and plants and equipment would have been 5 to 7 percent less between 1971 and 1978 if the capital gains provision did not exist.[38] If timber-growing alone were the sole purpose of the capital gains provision, however, other tax options (such as investment tax credits) would be a more direct route to assure that Federal tax expenditures were contributing to management. Current Federal revenues foregone because of the provision are about $500 millon per year, two-thirds of which goes to corporations, one-third to individuals.

Deductibility of Reforestation Costs—In 1980, Congress amended the IRS Code to permit "above the line" deductibility of certain reforestation expenses—up to a maximum of $10,000 annually under certain circumstances—with associated limited income tax credits. Under the amortization schedule established by the 1980 law, a landowner needs to incur reforestation expenses of $10,000 per year for 7 years before the maximum deduction can be taken. Although directly linked to reforestation expenditures, this tax provision is not likely to affect significant acreage since it currently covers reforestation costs of about 100 acres per landowner (assuming $100 per acre in costs). Current Federal tax expenditures accruing from the program are $20 million to $30 million per year—about 200,000 to 300,000 acres, assuming $100 per acre reforestation costs. Most of these benefits now go to corporations, but the individual share is expected to increase in the next 2 or 3 years as noncorporate owners become more aware of the program.

Federal Estate Taxes—Several provisions in Federal estate tax law benefit people who inherit forestland. Heirs are exempt from Federal estate taxes on gains in property values realized prior to forestland inheritance. The provision eases tax burdens on those who harvest inherited timber, and in theory it makes more money available to landowners for post-harvest management. Estate tax payments may be spread over a 10-year period if forest property comprises 35 percent of the estate's value and therefore may discourage premature cutting of timber stands to pay taxes. Forestland may be assessed for estate tax purposes according to its current use rather than for its market value—a provision which also theoretically removes incentives to prematurely cut timber. The requirements for use of this benefit are strict, however, and are thought by some to preclude its widespread use.

Casualties, Thefts, and Condemnations—Deductions are permissible for timber losses due to fire, storm or other casualty, theft or condemnation by a public agency if the timber is not salvageable and not covered by insurance. Although not a tax provision, the Federal Crop Insurance Act of 1980 (Public Law 96-365) authorized a pilot program related to insurance against risks and losses associated with forest industry needs (including appreciation). The initial pilot program is not expected to begin until late 1983.

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[38] Joseph E. Carrier, et al., *Economic Considerations Relating to Capital Gains Taxation of Timber Income*, report prepared for Forest Industries Committee on Timber Valuation and Taxation, Stanford Research Institute, September 1981, p. 58.

is jointly administered by the Forest Service and the Agricultural Stabilization and Conservation Service. Between its 1973 inception and 1981, some $88.8 million in FIP cost-sharing assistance was delivered for timber stand improvement and reforestation on about 2.2 million acres of private forestland. FIP assistance is restricted to owners of between 10 and 1,000 acres (5,000 acres under certain circumstances) and to sites capable of producing 50 ft³/acre annually in natural stands.

A recent evaluation of the FIP program by the Forest Service and the University of Minnesota concluded that the program has gained in efficiency over time.[60] The average size of tracts has increased and 70 percent of the treated acres in 1979 were on timberlands capable of producing 85 ft³/acre/year in natural stands. Nonetheless, most of the treated sites in 1979 were small (41 acres for reforestation and 31 acres for timber stand improvement), and about 6 percent of the acres treated in 1974 had not been retained by the owner through 1981. Several States have established their own forestry incentives programs since FIP was enacted. The Reagan administration, in its fiscal year 1984 budget proposal, has requested that Congress consolidate FIP with the Agricultural Conservation Program and has sought no funds for FIP.

Three 1978 enactments—the Cooperative Forestry Assistance Act (Public Law 95-313), the Renewable Resources Extension Act (Public Law 95-306), and the Forest and Rangeland Renewable Resources Research Act—placed additional emphasis on technical assistance, research, education, and information programs for private forestry. These programs have the potential to reach more landowners than direct cost sharing, but funding has been limited, especially for education and information. In addition, several Federal environmental laws have direct and indirect effects on timber management on private lands (see box K).

For many years, State governments have provided forestry-related technical and information services to forestland owners, as well as fire suppression and other extensive management assistance. Currently, these programs are supported by the Forest Service's Rural Forestry Assistance Program.

Recently, State legislatures have expanded forestry-related activities. A 1981 survey by the National Conference of State Legislatures found significant modifications in State programs during the 1970's[61] (table 37). State programs at the end of 1981 included:

- preferential forestland tax treatment in at least 22 States;
- six cost-sharing programs, either independent of or supplemental to the Federal Forestry Incentives Program;
- 15 State forest practices acts that regulate harvesting activities, environmental practices or reforestation;
- other initiatives designed to retain forestland in productive use; and
- forestland retention provisions of various kinds.

Most of the State programs are intended to encourage timber production and management. Some State forest practices acts, however, have more complex objectives, including environmental protection which in some instances may have negative effects on intensified forest management. California's law (California Public Resources Code Division 4, ch. 8), which is the most stringent, is believed by some to actually discourage timber management, even though one of its goals is to improve it, because of high compliance costs. One analyst makes informal estimates of $10 to $40 per thousand board-feet for additional costs resulting from implementation of practices required by law and concludes, " . . . it seems quite unlikely that the costs associated with rule requirements are likely to have much effect on the magnitude of operations, except in a limited number of marginal cases. Quite clearly, however, the net returns from timber harvesting to some stumpage owners have been significantly reduced."[62]

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[60] Christopher D. Risbrudt and Paul V. Ellefson, *An Economic Evaluation of the 1979 Forestry Incentive Program* (St. Paul, Minn: University of Minnesota, Agricultural Experiment Station 550, 1983).

[61] Cited in Gordon Meeks, Jr., "State Incentives for Non-Industrial Forests," *Journal of Forestry,* January 1982, pp. 18-22.

[62] Henry J. Vaux, "State Interventions on Private Forests in California," paper presented at the National Conference on Coping with Pressures on U.S. Forestlands, sponsored by Resources for the Future, Mar. 30-31, 1981, Washington, D.C., p. 35.

Box K.—Environmental Regulations and Timber Management

Environmental damage is to some extent unavoidable in timber harvesting and management activities, but many of these impacts can be ameliorated through environmentally sound management. Environmental protection is a key management objective of congressional policy articulated for Federal lands. Several recent Federal and State laws related to water quality, air pollution control, and chemical use affect forest management activities on private lands, although often less directly. These laws have been cited as potential barriers to more intensive timber management, but empirical evidence that this is the case is limited to relatively few instances.

Clean Water—Certain provisions of the Federal Clean Water Act (33 U.S.C. 1251 et seq.) affect forestry activities, but to date implementation of these provisions has not substantially impeded silvicultural activities. The act's section 208—aimed at reducing nonpoint pollution (including that which results from timber harvesting and other silvicultural practices)—has been implemented primarily through State level educational efforts and voluntary compliance with forest practice guidelines. It is not known whether these voluntary guidelines have been widely adopted by PNIF owners or how widely the guidelines diverge from common practices, but it appears unlikely that timber production would be significantly affected by compliance. Some foresters feared that section 404 of the act would restrict some practices for crossing streams and forest drainage areas, especially in the South where wetlands abound. To date, however, forest managers apparently have been successful in qualifying for exemption from 404 provisions or in obtaining the necessary permits to conduct forestry operations. The extent to which 404 restrictions may diminish forest productivity or discourage landowners from intensifying management is speculative but appears to be minimal.

Clean Air—Prescribed burning of forestlands is regulated under particulate emission provisions of the Clean Air Act (42 U.S.C. 7401 et seq.), and forest management interests have feared that these restrictions may impair managers' ability to effectively use fire as a silvicultural tool. However, OTA found no evidence that burning activity has been significantly constrained. Permit and notification requirements do not appear to be burdensome, and smoke management regulations seem to restrict scheduled burning activity only rarely.

Chemical Use—Regulation of chemical uses under the Federal Insecticide, Fungicide, and Rodenticide Act (92 Stat. 819-838) is restricting timber management activities in some regions. The most important restriction is a ban on forestry uses of 2,4,5-T, but the effect of the ban on forest productivity is uncertain. Some States' legal requirements for applicator licensing and water monitoring, coupled with rising insurance premiums, may result in higher costs of chemical application.

Table 37.—Selected State Activities Related to Private Forest Management, 1981

State	Cost sharing	Tax provisions	Forest practice acts	Retention of forestland
Alabama[a]	Considered but not adopted	Fixed assessment rate on land. Timber exempted from ad valorem. Severance on timber	Voluntary with recommended guidelines for nonpoint source pollution[b]	—
Alaska[a]	Authorization exists but no appropriation to date	No special tax treatment	Requires reforestation of all public and private harvested lands; regulates harvesting practices	Authorization exists for retention of forestland in State ownership for multiple use, but no lands designated
Arizona	—	Ad valorem with market-value assessment on forestland and timber on more than 40 acres	—	—
Arkansas[a]	—	Use value assessment on productivity of forestland. Severance tax on timber products. Five cents per acre fire protection tax	—	—
California[a]	80- to 90-percent cost-sharing for reforestation. Timber stand improvement and land conservation—1978	Use valuation on zoned land; yield tax on severed timbers	Comprehensive regulations to maintain timberland productivity water quality, and other values	Favorable tax treatment is conditioned on timberland preserve zoning; permit is required to convert
Colorado	—	Ad valorem tax on land; conditional exemption of increased value as result of planting	—	Educational program to promote multiuse
Connecticut[a]	—	Use valuation on land; yield tax on land and timber	—	Open-space law provides favorable tax treatment for classified timberland
Delaware	—	30-year exemption for established commercial plantation of 5 acres or more	—	—
Florida	Considered but not adapted[c]	Forestland valuation based on potential yield according to site index as an annual ad valorem tax on capitalization of net income expected from yield	—	—
Georgia	—	No special treatment for forestlands	—	—
Hawaii	—	Use valuation on land; yield on severed timber. Private lands under public management are exempted	—	Statewide zoning by land-use commission provides some protection
Idaho	—	Yield tax on severed timber; 61 per acre assessment on land[d]	Requires reforestation and regulates harvesting practices[b]	—
Illinois	Considered and defeated in legislature 1979 and 1980	No special treatment for forestlands	—	—
Indiana	—	Lands classified as forest are eligible for $1 per acre assessment	Classified forestlands must meet minimum management standards	Tax provision of the Forest Classification Act encourages retention
Kansas	—	Use valuation is authorized but not implemented	—	—
Kentucky[a]	—	Use valuation on land; standing timber is included in land valuation	—	—
Louisiana	Considered but not adopted	Use valuation on land; severance tax on timber	—	—
Maine	—	Tree Growth Law provides productivity valuation; standing timber included with land	Land Use Regulation Law regulates harvesting in shore lands and hazard areas	—
Maryland	—	Assessment limits on classified lands; income tax credit being considered	Forest Conservancy Law and Pine Reforestation Law	Forest Conservancy Law and its tax provisions are intended to encourage retention

Table 37.—Selected State Activities Related to Private Forest Management, 1981 (continued)

State	Cost-sharing	Tax provisions	Forest practice acts	Retention of forestland
Massachusetts	—	Land is taxed at fixed rate; yield tax on severed timber	Slash reduction, wetlands protection, and harvesting plans are required	Forest Tax Law is intended as incentive for retention
Michigan	—	Classified forestland is taxed at a fixed rate; yield tax on timber	—	—
Minnesota	50-percent cost-share for 7-county area administered by Soil and Water Conservation District, 1979	Productivity valuation on land plus yield tax at fixed rate on land. Valuation on timber is at fixed rate and according to management agreement[d]	—	—
Mississippi	75-percent cost-sharing program funded by severance tax with $37 per acre limit, 1974	Ordinary property tax on land; severance tax on timber	Mississippi forest harvesting law	—
Missouri[a]	—	Fixed assessment on classified land (voluntary tax law); yield tax on timber harvested from classified land only	—	—
Montana	—	Land is assessed by productivity and accessibility for ad valorem taxes	—	—
Nebraska	—	Related to grassland value	By executive order, owners must have State approval for tree cutting	—
Nevada	—	Use value assessment on classified land; yield tax on severed timber	Very extensive seed-tree requirements and strict harvesting standards	—
New Hampshire	—	Use valuation on land if certified as tree farm; yield tax on severed timber[c]	Several laws regulate timber harvesting techniques[b]	—
New Jersey[a]	—	Use value assessment base on productivity	Voluntary with recommended guidelines for nonpoint pollution	Pineland Protection Act limits development and encourages forestry or agricultural use on 1.1 million acres
New Mexico[a]	—	Productivity valuation on land; severance and excise tax on timber	Forest Conservation Act requires reforestation, seed tree, harvesting standards, and fire prevention	—
New York[a]	—	Forestland is assessed at a reduced rate; yield tax	Extensive technical assistance including management planning and timber marking	Tax treatment is intended to encourage retention and management of forestland
North Carolina[a]	60-percent cost-sharing on a maximum 100 acres per year funded by primary products assessment and State appropriations, 1978	Use valuation on land; exemption for standing timber. Amortization of timber receipts	—	—
North Dakota	—	Differential valuation in lieu of ad valorem taxes on land and timber	—	—
Ohio	—	Forestland is taxed at 50 percent of normal rates; use valuation is optional	—	—
Oklahoma	—	Market valuation on land; ad valorem on timber	Voluntary guidelines developed by forestry committees[b]	—
Oregon[a]	Considered but not adopted[c]	Use valuation on land; income tax credit for reforestation capitalization of income over rotation; yield tax on timber	Practice Act provides for reforestation, roading, harvesting, chemicals, and slash burning	State land-use law requires local use plans to conform with State goals and guidelines

Table 37.—Selected State Activities Related to Private Forest Management, 1981 (continued)

State	Cost-sharing	Tax provisions	Forest practice acts	Retention of forestland
Pennsylvania	—	Use or productivity valuation on forest reserves	—	Assessment Act of 1974 intended to stimulate retention
Rhode Island	—	15-year exemption, or use valuation on land	—	1980 revisions allow present value assessment on lands with management plan
South Carolina	75-percent cost-sharing for reforestation, 1981	Fixed assessment based on value and productivity of land	Voluntary guidelines by forestry association[b]	—
South Dakota	—	Ad valorem at market rates on land and timber	—	—
Tennessee	—	Current-use valuation on land and timber on classified forestlands	—	1976 current use tax law is intended to preserve forest, agricultural, and open-space land
Texas	Texas Reforestation Foundation funded by industry for 65-percent cost-sharing. Initiated 1981—no legislative action	Assessment on land based on capitalized value of average net income over preceding 5 years	—	—
Utah	—	Timberland is assessed as grazing land	—	—
Vermont	—	Use valuation on managed forestland	—	Use value appraisal law is intended to encourage forest and agricultural land conservation
Virginia	75-percent cost-sharing for reforestation of pine up to $90 per acre, 1970	Use valuation on classified land; severance tax on timber reforestation on nonindustrial public forests is funded by industry tax	Seed trees must be left after harvesting, or some other plan made for ensuring regeneration	Land-use tax of 1971 is intended to preserve agricultural forest, and open-space lands; Agricultural and Forest Districts Act authorizes zoning
Washington	—	Fixed tax on land plus yield tax on land and timber, or optional use valuation; severance tax on timber	Minimum reforestation standards and harvesting guidelines	Conservation of forestland is intended by tax incentives
West Virginia	—	Severance tax on timber	Voluntary by State Forest Practice Standards Committee[b]	—
Wisconsin[a]	—	10-year fixed rate assessment per acre on land plus 10-percent yield tax on stumpage value	—	Tax structure intended to prevent forests from destruction
Wyoming	—	Ad valorem	—	Mineland Reclamation Act includes restocking of mined forestlands

[a] Responded to request for review with corrections and comments.
[b] Sources: Elletson and Cubbage (1980), and Klein (1980).
[c] Source: N. Williams, "A Study of State Cost-Sharing Programs for Reforestation and Timber Stand Improvement on Nonindustrial Private Forests," unpublished report, U.S. Forest Service, Washington, D.C., 1978.
[d] Source: Forest Industries Committee on Timber Valuation and Taxation (1979).

SOURCE: Gordon Meeks, Jr., "State Incentives for Non-Industrial Private Forestry," *Journal of Forestry*, January 1982.

APPENDIX

APPENDIX

Glossary of Terms

Baling—The process of compressing pieces of wood into a dense package or bale.

Best opening face (BOF)—A computer program, developed at the U.S. Forest Products Laboratory, that determines the optimum sawing pattern to use on a log to maximize its lumber yields.

Biomass—The total mass, at a given time, of living organisms of all species in a natural community. In this report, biomass is used to describe the total mass of woody plants, unless otherwise specified.

Bleaching—The chemical treatment of pulp to increase its brightness.

Bristol—Cardboard with a smooth surface suitable for writing or printing.

Bucked log—A log that has been cut into smaller lengths.

Burst strength—A measure of the ability of a sheet to resist rupture when pressure is applied by a specified instrument under specific conditions.

Cellulose—The major chemical constituent of plant cell walls; a long chain polymer formed from glucose units.

Chemical pulping—The process of obtaining pulp by cooking wood chips in acids, alkaline, or neutral salt solutions under pressure and high temperatures. This process breaks down the wood structure and dissolves some or most of the lignin and hemicellulose contents.

Chips—Small pieces of wood used to make pulp. The chips are made either from wood waste in a sawmill or plywood plant, or from pulpwood specifically cut for this purpose.

Coated paper—Printing paper that has been coated with materials that improve its printability and photo reproduction.

Cogeneration—The combined production of electricity and useful thermal energy in one process.

Commercial forestland—All forestland capable of growing 20 ft^3 of industrial roundwood per acre annually in a natural stand that has not been withdrawn from timber harvesting by statute or administrative action. This designation does not necessarily imply that the land is currently being used for commercial timber production.

Com-ply—Flat plywood-like panels or lumber-like pieces with particleboard cores and wood veneer faces.

Composite lumber—Lumber made from small wood pieces, usually chips or veneers glued together.

Converted paper products—Paper that has been converted to product form, such as envelopes, tissues, boxes, cartons, and printing and writing papers.

Coppice system—A silvicultural system in which timber crops originate from cutover stumps from which shoots develop into mature timber. Coppice harvesting and growth cycles can be repeated as long as the supporting root system remains sufficiently productive.

Cover crop—A subsidiary crop of low plants introduced in the earlier stages of planting to protect the land from erosion and to suppress weeds.

Cull trees—Individual trees which, because of certain defects, fail to meet standards for commercial exploitation.

Disking—Cultivating with an implement (such as that used in farming) that turns and loosens the soil with a series of disks.

Edge, glue, and rip (EGAR)—A sawing and gluing technique that reduces wood loss during milling and permits use of low quality raw materials to make high-quality lumber-like products.

Feller-buncher tree processors—A self-propelled machine used to cut trees by shearing them off near the ground, then move bundles of logs across the ground surface using a hydraulic apparatus.

Fiberboard—Panels composed of wood fibers, usually glued together. They have extremely flat and smooth surfaces and edges.

Flakeboard—Particleboard with surfaces composed of flakes or composed entirely of flakes.

Forage—Edible vegetation available for livestock or wildlife grazing.

Fuelwood—Wood removed directly from the forests primarily to burn as fuel (firewood) for residential heating. Fuelwood is one type of "wood fuel".

Groundwood pulp—Pulp produced by grinding wood between stone surfaces or between sets of metallic bars in a refiner.

Growing stock—The net volume of live sawtimber and poletimber trees from the stump to a minimum four inch top of the central stem or to the point where the central stem breaks into limbs.

This definition includes most wood used by the forest products industry; however some timber supplies are derived from nongrowing stock sources such as salvageable dead trees.

Hardboard—Flat panels made of individual wood fibers, usually glued together. They are graded according to density.

Hardwood—One of two broad classes of timber, usually characterized in the tree by broad leaves that fall off each year. Examples include oak, elm, and ash.

Harrowing—Cultivating with an implement set with spikes, spring teeth or disks used primarily for pulverizing and smoothing the soil.

Industrial roundwood—Wood harvested for use as an industrial raw material rather than as fuel. Note: Residues derived from industrial roundwood are often used as wood fuels.

Intensive forest management—A general term used to distinguish active versus passive treatment of specific forest sites. As used in this report it refers to application of planned treatments to forestland to enhance the quality and/or quantity of industrial timber. Management intensity varies from simple procedures such as thinning of stands for improved growth to complex use of genetic and chemical technologies. Costs of intensive management vary accordingly. The technologies used are further described in chapter V.

Kraft—A strong paper or board made from woodpulp derived from chips boiled in an alkaline solution containing sodium sulfate.

Lathing—The process of peeling logs to yield veneer for plywood.

Lignin—The noncarbohydrate, structural component of wood that encrusts the cell walls and cements the cells together. Its exact composition is unknown.

Linerboard—Stiff, durable, thick paper made primarily from bleached sulfate kraft pulp and used as a facing sheet on corrugated box material or in material for solid fiber containers.

Log—Any section of the trunk or of the thicker branches of a felled tree after trimming.

Lumber—Beams, planks or boards produced by sawing logs and used primarily for construction.

Mechanical pulping—The process of producing pulp by use of a machine known as a defibrator in which wood chips from debarked logs are physically ground or are passed through a mill.

Millwork and molding—Units of wood completely manufactured and assembled ready for putting in place; doors, window frames, etc.

Multiple use—Any forest management policy which seeks to simultaneously fulfill several distinct objectives. In the case of National Forest System and Bureau of Land Management lands, these objectives are mandated by law and include recreation, timber, wildlife, and watershed management.

Multispan logging—A type of skyline logging where the cable is stretched between several posts or trees.

Naval stores—A wide variety of chemical products extracted from wood, including pitch, rosin, turpentine, and pine oils. The term dates back to the days when wooden vessels were caulked with pine tar and pitch.

Newsprint—A coarse textured paper of low strength and limited durability which is made from mechanical or semimechanical pulp, which uses either hardwoods or softwoods.

Nondeclining even flow—The harvest policy on National Forest lands which seeks to ensure sustained yield in perpetuity without diminishing harvest levels; however temporary departures from this policy are permitted under certain circumstances.

Oriented strand board—Flat plywood-like panels made with alined strand or ribbon shaped pieces of wood, sometimes crossbanded (strands in different layers oriented perpendicular to adjacent layers), sometimes veneered.

Pallet—A low wooden platform, sturdy and portable, on which material is stacked to facilitate handling and shipping.

Panel product—Any composite wood sheet including plywood, particleboard, fiberboard, and veneer.

Paper and paperboard—All primary and converted paper products including newsprint, printing and writing paper, and paperboard. This term does not include waste paper and waste paperboard unless otherwise specified.

Paperboard—A pulp product which is typically stiffer and thicker than paper; it includes linerboard and corrugated boxes.

Parallel laminated veneer (PLV)—A composite product made of layers of veneer laid with the grain going in the same direction and united with an adhesive or mechanical fastener.

Particleboard—A general term for flat panels manufactured from wood particles which are bonded together with synthetic resin or other suitable binder under heat.

Planing mills—Mills which plane or smooth the surface of sawn timber.

Platform frame—The traditional American 2 × 4 method of building a house.

Plenum system—An underfloor wood construction heating/cooling system in which air pressure is built up under the house, pushing air into the rooms of the house without using ducts.

Plywood—Flat panels, usually 4 ft by 8 ft and less than 1.5-in. thick, consisting of laminated hardwood or softwood veneers. The grain direction of each ply or layer is usually at right angles to the ones adjacent to it. The veneer sheets are joined, under pressure, by a bonding agent.

Press drying—A new papermaking technology which both reduces the amount of energy required in the papermaking process and enables the greater utilization of some hardwood species.

Primary paper products—All paper and paperboard except converted products; includes linerboard, newsprint, etc.

Productive deferred forestland—Land that has been temporarily withdrawn from timber utilization pending government action.

Productive reserved forestland—Productive public forestland withdrawn from timber utilization through statute or administrative action.

Pulp—A processed wood fiber in which varying amounts of lignin have been removed in preparation for making paper.

Pulping liquors—A general term which refers to the different chemicals used in the pulping process. "White Liquor" is the original sodium sulfide and sodium hydroxide solution. "Black Liquor" is the liquid rich in lignin salts and other organics removed from wood in the pulping process. The salts remaining after the water is removed and the remaining viscous solution is burned in a recovery furnace (mostly sulfides and carbonate of soda) form a molten stream known as smelt and are recombined with water to form "Green Liquor."

Rayon—A synthetic fiber made primarily from wood by the viscose process using pure cellulose produced by the dissolving pulp process. Its properties are similar to those of cotton.

Roadless area review and evaluation (RARE)—An administrative review of national forests to identify potential wilderness areas for congressional consideration. There have been two such reviews, RARE I and RARE II.

Roundwood—Logs, bolts, or other round sections cut from trees.

Saw, dry, rip (SDR)—A process which allows greater use of hardwoods for lumber manufacture by reducing their tendency to warp and deform.

Sawlines—The lines or cuts that a saw follows through the wood.

Sheathing—A wooden covering laid over the exterior framework of a structure for attachment of roofing and external wall coverings; often consists of particleboard and plywood.

Silviculture—The science and art of cultivating forest trees by tending, harvesting, and replacing them in a way which results in the planned production of tree crops.

Skidding—A loose term for hauling timber by sliding it along the ground.

Skyline logging—A method of power cable logging in which a heavy cable is stretched between upright supports, the whole functioning as an overhead track for a log carrying trolley.

Softwood—One of the two broad classes of timber, usually characterized in the tree by needlelike or scalelike leaves that persist year after year. Examples include Douglas fir, hemlock, pine, and spruce.

Solid wood products—All wood products except pulp, paper, paperboard, and derived products.

Stand regeneration—The establishment of a new timber crop. The three major regeneration methods are planting, seeding, and natural regeneration.

Stocking—The extent to which forestland is occupied by trees of specified classes. Classification of forestland and forest types are based on stocking of all live trees. Classification of condition classes are based on stocking of desirable trees.

Stumpage—Uncut standing timber.

Sustained yield management—Silvicultural systems designed to achieve perpetually a continuing balance between forest growth and harvest.

Tariffs—An official schedule of taxes imposed on imported and less commonly exported goods, either in the form of a percentage of their value or as an amount per unit of measure.

Tensile strength—The capacity of a body to sustain equal and opposite forces tending to lengthen it in that direction. In wood, tensile strength is high along the grain and low across it.

Thermomechanical pulping—In this process wood chips are continously fed into a steam heated chamber with mechanical separation of the fibers taking place at high temperatures.

Traditional quotas—Formal quantitative limits placed on imports.

Truss framing—A method of homebuilding based on braced framing designed to transfer structural loads to the supports.

Veneer—A thin sheet of wood of uniform thickness, produced by rotary cutting, slicing, or sawing.

Waferboard—Flat panels made with wafers or large chips of wood glued and pressed together; generally used in structural sheathing.

Waste paper—Paper or paperboard collected for reuse either as raw material for new paper and paperboard or as a fuel.

Wilderness—Federal lands designated by Congress under The Wilderness Act of 1964 and subsequent legislation for protection and management to preserve natural conditions. Wilderness areas generally show little evidence of human activity, provide outstanding opportunities for primitive and unconfined recreation, are at least 5,000 acres or more, and have important scientific, educational, scenic, or historic values.

Wood fuel—Any wood or wood derived source of fuel including fuelwood (firewood), byproducts of wood processing and manufacturing subsequently used as fuel, and specially processed wood products specifically made for use in energy production.

Woodpulp—Pulp manufactured from either softwood or hardwood trees either by mechanical means, chemical means or both.

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Office of Technology Assessment

The Office of Technology Assessment (OTA) was created in 1972 as an analytical arm of Congress. OTA's basic function is to help legislative policymakers anticipate and plan for the consequences of technological changes and to examine the many ways, expected and unexpected, in which technology affects people's lives. The assessment of technology calls for exploration of the physical, biological, economic, social, and political impacts that can result from applications of scientific knowledge. OTA provides Congress with independent and timely information about the potential effects—both beneficial and harmful—of technological applications.

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